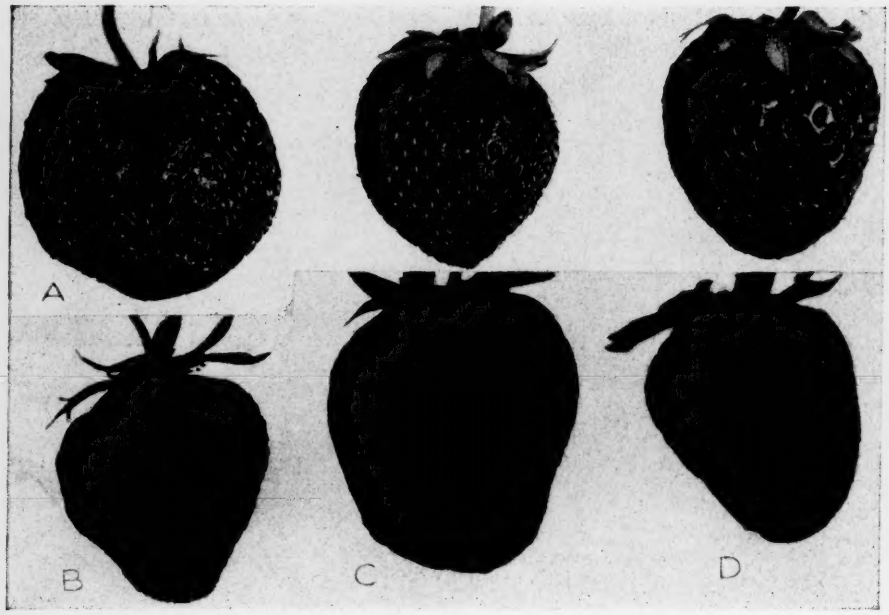
The Journal of HEREDITY



INCREASED DEGREE OF VITAMIN C

(SEE PAGE 363)

The Declining College Birthrate

The Fraction Method—A Teaching Aid

An Unusual Reaction to P.T.C.

A New Mouse Mutant

Apple Sports

Title Page and Index to Volume 38

VOLUME 38 DECEMBER, 1947 NUMBER 12

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION at 32nd Street and Elm Avenue, Baltimore 11, Md., and 1507 M St., N. W., Washington 5, D. C. Address all communications regarding editorial matters to 1507 M. St., N. W., Washington, D. C. Communications regarding the business management of THE JOURNAL OF HEREDITY may be addressed to the publication office, 32nd Street and Elm Avenue, Baltimore, Md., or to 1507 M St., N. W., Washington 5, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in section 1103. Act of October 3, 1917 authorized December 29, 1918.

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$4.00 a Year. 40c a Copy. Prices of back numbers on application.

The

Journal of Heredity

Vol. XXXVIII **DECEMBER, 1947** **No. 12**

CONTENTS

THE COLLEGE BIRTHRATE
By Clarence J. Gamble 355

BREEDING STRAWBERRIES FOR VITAMIN C
By George M. Darrow, Marguerite S. Wilcox, D. H. Scott and Margaret C. Hutchins 363

THE FRACTION METHOD OF ANALYSIS OF FACTORS
By Melvin D. Jones 368

CHIMERAL SPORTS OF APPLES
By John Einset, H. Weston Blaser and Barbara Imhofe 371

ODD FAMILIAL P.T.C. REACTION
By F. B. Hutt 377

MUTANT WHITE MICE
By Arnold Grobman and Donald R. Charles 381

Reviews and Notes

R. A. EMERSON 353

TONGUE CURLING 365

HOW MANY A'S IN AARDVARK? (*Review*) 366

POSTSCRIPT ON THE DIABETES-NON-TASTING CORRELATION 378

NOTE ON CERTAIN MENDELIAN RATIOS IN MINK
Larry Moore and Clyde E. Keeler 380

MAD AND MUDDLED (*Review*) 384

Title Page and Index to Volume 38 385

R. A. EMERSON
1873-1947

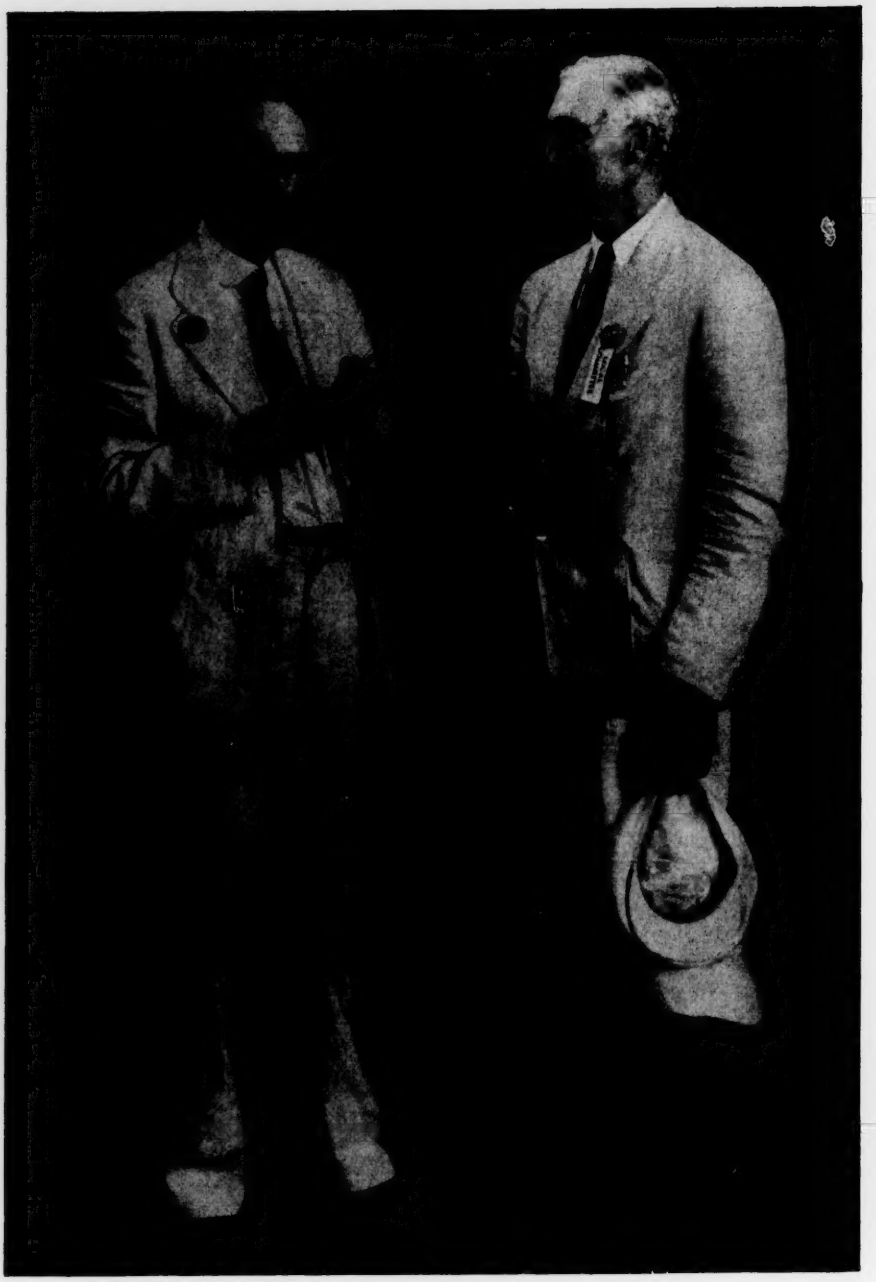
EVERY geneticist will feel a sense of personal loss in the death of Dr. R. A. Emerson at Ithaca, New York, on December 8, 1947. Dr. Emerson made notable contributions to the genetics of maize, but even more than that he pioneered a new technique in science—the pooled-experience attack on complex research problems.

Science has up until now been perhaps too much the province of the ultra-individualist lone-wolf researcher, often frantically jealous of his own discoveries, and almost pathologically identified with his brain-children — the working hypotheses which are the conceptual framework we build new facts around. We have come a long way since Bacon could boast that he "took all knowledge for his province." Today the scope and detail of science is such that to surround the whole of it is beyond the scope of the most gigantic intellect. Even in highly specialized compartments of research the working unit is increasingly becoming the team.

Emerson was perhaps the first to realize the need for a continuous interchange of knowledge between the different workers in a given field. His was the operating center for the cooperative pooling of new knowledge in the field of maize genetics which was perhaps the first development of group research on a subject-matter basis in the history of science.

With characteristic modesty Emerson disclaimed any credit for inventing the maize-geneticists' round robin. But it was more than coincidence that the idea happened to sprout at Ithaca and that Emerson's office became the nucleus of this new idea. As to the fruits of such

(*Continued on page* 390)



EMERSON AND MORGAN IN 1932

Rollins Adams Emerson (*at right*), a member of the Advisory Committee of the American Genetic Association for many years, was a pioneer plant breeder and geneticist from the turn of the century when genetics was in its infancy until his death in December 1947, age 74. He is shown here with the late T. H. Morgan at the Sixth International Genetics Congress at Ithaca. See page 353 for a tribute to Dr. Emerson. (Photograph by Trevor Teale.)

THE COLLEGE BIRTHRATE

CLARENCE J. GAMBLE, M.D.
Milton, Mass.

I—THE CURRENT SITUATION

IN this intricate technological age, highly trained specialists in large numbers are needed to man the great complex of delicate organizations, industrial, political, educational, etc., that constitute a modern nation. The greatest single reservoir of those possessing the requisite abilities, the ability to plan, to guide, to execute with intelligence, is the group of college-trained citizens. This higher intelligence is not the magical effect of the sixteen years of education which leads to a college degree. It is simply that sixteen years of progressively more advanced learning constitutes a more or less rigorous selective process, and those who vault the final hurdle to achieve a diploma tend to be the cream of the crop that started the race back in kindergarten. This was confirmed by the results of the 10,000,000 intelligence tests given the selectees by the army. In these tests, the college graduates had an average record better than 94 per cent of all men examined.

Obviously this does not mean that all the intelligent citizens of the United States have attended college. As a matter of fact, of the highest six per cent in the army tests, only a quarter had college diplomas. The remainder, distributed throughout the entire population, are of equal eugenical interest but data on them are harder to obtain. College graduation is a criterion that is readily applied in selecting those of high intelligence. It is a convenient sampling technique — and one widely used — which serves perfectly the ends of this paper.

By reason of these considerations, the fecundity of this group is a matter of great significance. Since children tend to inherit the intellectual capacity of their parents,* the average of the children of graduates will be above that of the nation as a whole. The object of this study is to determine the rate at which college graduates are replacing, or failing to replace, themselves.

This is not the place to detail the demographic and statistical niceties that go into the computation of the "replacement rate." Suffice it to say that in order for the population of the United States to replace itself with an equal number of adults of reproductive age in the next generation, it is computed that approximately 2.2 children (live births) must be born per woman of reproductive age. Assuming a somewhat lower mortality rate among children in the group under consideration, it is believed that *to accomplish replacement approximately 2.1 children are needed for each college graduate.*

Historical Background

In the early 1700's the graduates of Yale produced, on the average, five surviving children each.[2] Recent history, however, is less encouraging. For classes graduating about 1825 the number had fallen to 3.5 per graduate, while for those graduating in the decade of the 1870's from Harvard, Syracuse, and Yale[3,4,2] the number of children were well below the 2.1 necessary for replacement. The Harvard classes of the 1890's fell to 1.45 children per graduate.[3] A moderate rise from this low level was shown by the classes of 1912-1913 at Princeton[5] with 1.64, while for the classes of 1916-1920 at Harvard[6] this

*See Cyril Burt[1] (p. 14, Table I).

had increased to 1.73. A portion of this decrease in offspring is due to the low marriage rate of the college graduates. For example, among graduates of Harvard in the last half of the 19th century, only approximately 75 per cent married.

A startling contrast to college birth-rates is provided by a study of the genealogical records of pioneer families which reveal that the average number of children per pioneer wife in the years before 1700 was 7.37.[7] The earliest information we have on the fecundity of women college graduates comes from classes graduating during the 1870's at Mt. Holyoke and Vassar. Here the children numbered about 2.5 per married alumna.[8] At the turn of the century Wellesley graduates were producing an average of 1.02 children per graduate,[9] with 1.1 children per graduate reporting for Smith, Vassar, Mt. Holyoke[8] and Illinois University.[10] Partly responsible for the low birth-rate is the low marriage rate among these classes, averaging only approximately 55 per cent.

The Twentieth Century

Earlier reports on the fecundity of college graduates have been based on those who graduated in the first two decades of this century. Between 1900 and 1920 genetics was emerging as a distinct scientific discipline in its own right. By the 1920's, the genetic implications of human evolution were being taught in a good many college curricula. Prior to that time the question of the reproductive responsibility of any particular individual had been given very little consideration. For that reason, a study of the fecundity scores of those who graduated from college in 1921 and 1922 throws light on the reproductive

TABLE I.—Children per male graduate—1922 and 1921. Colleges with 80 per cent or more of the graduates with known address reporting are indicated in capitals.

1922 MEN	Per Reporting Grad.	1921 MEN	Per Reporting Grad.
MONTANA STATE	2.31	U. of Utah	3.05
U. of Idaho	2.28	Allegheny, Pa.	2.54
HANOVER, IND.	2.10	Mississippi	2.53
Occidental, Calif.	2.10	U. of Vermont	2.45
Kalamazoo	2.06	Kalamazoo	2.22
Yale	2.03	Grove City, Pa.	2.20
Furman U., S. C.	2.00	Colgate U., N. Y.	2.18
Oberlin	1.95	U. of New Hampshire	2.04
Dartmouth	1.93	Ohio U.	2.00
Allegheny, Pa.	1.90	Mass. Inst. of Tech.	1.98
Central Michigan C. of Ed.	1.82	ST. OLAF, MINN.	1.98
WESLEYAN U., CONN.	1.79	Oregon State C.	1.90
UNION, N. Y.	1.74	Amherst	1.88
Oregon State	1.78	Carleton, Minn.	1.88
Bucknell U., Pa.	1.71	Oberlin	1.88
Trinity U., Texas	1.70	BEREA, KY.	1.80
Bowdoin	1.63	Boston U.	1.78
Washington and Jefferson, Pa.	1.61	Muhlenberg, Pa.	1.78
Pratt Inst., N. Y.	1.61	Bowdoin, Me.	1.76
Virginia Military Inst.	1.58	Tufts, Mass.	1.74
Polytechnic Inst. of Brooklyn	1.58	PRINCETON U.	1.71
HARVARD	1.57	Penn. State	1.68
BEREA, KY.	1.55	CORNELL U., N. Y.	1.66
U. of Arizona	1.53	St. C. of Washington	1.65
U. of Oregon	1.50	HARVARD	1.63
Tufts, Mass.	1.42	St. Lawrence U., N. Y.	1.62
JAMES MILLIKEN U., ILL.	1.20	Trinity, Conn.	1.62
MACALESTER, MINN.	1.20	DARTMOUTH	1.60
ILLINOIS	1.11	Knox, Ill.	1.58
		WESLEYAN U., CONN.	1.57
All Colleges	1.72	FURMAN U., S. C.	1.56
		N. E. Mo. St. Teachers	1.56
		Columbia U.	1.46
		UTAH STATE AGRIC.	1.40
		Clark U., Mass.	1.32
		All Colleges	1.76

patterns of this important group at a time when a change in attitudes might have been in process.

The 1940 Census made available for the first time regional and nation-wide statistics on the relative fecundity of various social, racial, educational, and economic categories of American women. Analysis of these data revealed that women aged 45 to 49 years who had not completed more than four years of schooling had 4 1/3 children each, while the college graduates in the same age-group reported only 1¼ children per woman graduate. That the inverse effect of education on fertility was progressive was suggested by the 2 9/10 children of women who had completed eight grades or less and the 1¾ children of high school graduates.[11]

The more recent data here reported were obtained by a survey sponsored by the Population Reference Bureau during the last two years. A questionnaire was offered to college registrars and to alumni secretaries to obtain information about the marital status and the number of children born to classes celebrating their twenty-fifth anniversary in 1946 and 1947. The registrars and alumni secretaries of 76 colleges returned tabulations of the children born to their alumni in the two classes graduating in 1921 and 1922. They are presented in Tables I-III.* They furnish a basis of comparison with the Census data and with earli-

TABLE II.—Children per female graduate—1922 and 1921. Colleges with 80 per cent or more of the graduates with known address reporting are indicated in capitals.

1922 WOMEN COLLEGES	Per Graduate†
SWEET BRIAR, VA.	1.64
C. OF NEW ROCHELLE, N. Y.	1.74
N. J. C. for WOMEN, RUTGERS U.	1.77
VASSAR	1.80
U. of Arizona	1.83
U. OF OREGON	2.19
Berea, Ky.	1.42
U. of Idaho	1.42
Hanover, Ind.	1.64
Oregon State	1.63
BRYN MAWR	1.58
AGNES SCOTT, GA.	1.46
WELLESLEY	1.38
H. S. Newcomb, La.	1.36
Montana State	1.32
Russell Sage, N. Y.	1.31
Occidental, Calif.	1.31
Bucknell U., Pa.	1.26
Goucher, Md.	1.24
Winthrop, S. C.	1.21
Oberlin	1.19
SIMMONS, MASH.	1.13
Huntingdon, Ala.	1.10
MOUNT HOLYOKE	1.10
ALLEGHENY, PA.	1.09
MACALESTER, MINN.	1.07
Jackson, Mass.	1.04
JAMES MILLIKIN U., ILL.	0.98
KALAMAZOO C.	0.95
Furman U. S. C.	0.89
WAYNESBURG, PA.	0.88
ILLINOIS C.	0.73
Adelphia, N. Y.	0.73
All Colleges	1.35

(Omitting those in each ratio for whom the the needed data are not available.)

†For the women, questonnaires were sent only to the married graduates, since the married and the single are easily segregated on the address lists. The number of children per graduate is computed by the formula:

$$\frac{\text{(Children Reported)}}{\text{(Married Grads. reporting)}} \cdot \frac{\text{(Married Grads.)}}{\text{(Total Grads.)}} = \text{children per grad.}$$

1921 WOMEN COLLEGES	Per Reporting Grad.
U. of Utah	3.12
Utah State Agric.	2.75
Carleton, Minn.	1.90
Oregon State	1.78
St. Olaf, Minn.	1.71
VASSAR	1.70
Allegheny, Pa.	1.65
Knox, Ill.	1.65
Fla. St. C. for W.	1.59
Agnes Scott, Ga.	1.56
Grove City, Pa.	1.53
Kalamazoo	1.53
WELLESLEY	1.52
Smith	1.51
U. of Vermont	1.44
U. of New Hampshire	1.42
JACKSON, MASS.	1.41
GOUCHER, MD.	1.40
Winthrop, S. C.	1.40
St. C. of Washington	1.38
MACMURRAY, ILL.	1.38
Texas St. C. for W.	1.38
Oberlin	1.34
PENN STATE	1.34
Simmons, Mass.	1.30
St. Lawrence U., N. Y.	1.27
Berea, Ky.	1.20
Huntingdon, Ala.	1.20
N. E. Mo. St. Teachers	1.20
CORNELL U., N. Y.	1.20
Mills, Calif.	1.17
Ohio U.	1.12
Boston U.	1.09
C. of New Rochelle	1.07
RUSSELL SAGE, N. Y.	1.00
H. S. NEWCOMB, LA.	0.91
Furman U., S. C.	0.80
ST. CATHERINE, MINN.	0.13
All colleges	1.43

*More detailed tables may be obtained from the author.

er findings, and make possible a more exact appraisal of the situation in terms of one-sex and coeducational colleges. The results cover more recent classes than those in the Census report, and include the children of male college graduates.

It should be noted that all figures cited in the tables and the text are computed on the basis of *individuals reporting*. The data on *all* individuals in a class, were it known, might well materially alter the class average.

The Classes of 1921-1922

What we find when we examine the data is what numerous investigators working with similar groups have repeatedly discovered; i.e., that the college educated segment of the population is failing to reproduce itself by an appalling margin.

The male graduates of the class of 1922 from 29 colleges report only 1.72 children each. This is a failure to replace themselves by 18 per cent. Nor were the results from 1921 more encouraging. Thirty-five men's colleges reported an average of only 1.76 children per graduate.

The women graduates are even less productive. Those of 1922 average only 1.35 children apiece, failing to replace themselves by 36 per cent. The women of 1921 from 38 colleges did only a little better, with 1.43 children.

The difference between the birthrates of the two sexes results largely from the difference in the numbers who married. While 92 per cent of the 1922 alumni married, only 75 per cent of the women did so. That their family plans were almost identical, and at an unfortunately low level, was shown by the 1.86 children for each married man and 1.81 for

TABLE III.—The winners. Five highest ranking colleges in various categories studied, for the classes of 1922 and 1921.

	MEN			WOMEN		
1922		1921		1922		1921	
A—Children per Graduate							
1. *Montana State	2.31	U. of Utah	3.05	*Sweet Briar	2.19	U. of Utah	3.12
2. U. of Idaho	2.28	Allegheny	2.54	*C. of New Rochelle	1.83	Utah S. Ag.	2.75
3. *Hanover, Ind.	2.10	Mississippi	2.53	N. J. C. for W.	1.80	Carleton	1.90
4. Occidental	2.10	U. of Vt.	2.45	*Vassar	1.77	Ore. State	1.78
5. Kalamazoo	2.06	Kalamazoo	2.22	U. of Orizona	1.74	St. Olaf	1.71
B—Children per Married Graduate							
1. *Montana State	2.85	U. of Utah	3.05	*C. of New Rochelle	2.63	U. of Utah	3.33
2. U. of Idaho	2.54	Allegheny	2.75	*Sweet Briar	2.57	St. Olaf	2.49
3. Furman U.	2.21	Kalamazoo	2.50	N. J. C. for W.	2.35	Allegheny	2.11
4. *Hanover, Ind.	2.10	U. of Vt.	2.49	*Vassar	2.26	*Vassar	2.00
5. Occidental	2.10	Grove City	2.20	*Bryn Mawr	2.18	Knox, Ill.	2.00
C—Children per Graduate with Any Children							
1. *Montana State	3.52	*Utah S. Ag.	3.47	*Macalester	3.00	Utah S. Ag.	4.40
2. *Macalester, Minn.	3.00	U. of Utah	3.21	*Waynesburg, Pa.	3.00	U. of Utah	3.57
3. U. of Idaho	2.75	Mississippi	3.04	*Sweet Briar	2.84	*St. Catherine	3.00
4. *Hanover, Ind.	2.62	Ohio U.	2.89	*C. of New Rochelle	2.84	St. Olaf	2.95
5. Yale	2.51	Allegheny	2.87	Hanover, Ind.	2.67	Fla. S. C. for W.	2.69
D—Percent of Graduates Who Married†							
1. *Hanover, Ind.	100	*St. Olaf	100	U. of Arizona	91	Berea, Ky.	100
2. Kalamazoo	100	Grove City	100	*Waynesburg, Pa.	88	Carleton, Minn.	95
3. Occidental	100	Knox, Ill.	100	Ore. State	87	Smith	95
4. Oberlin	100	U. of N. H.	100	Huntingdon, Ala.	86	U. of Utah	94
5. Cen. Mich. C. Ed.	100	N.E.Mo.St.Teach.	100	Russell Sage, N.Y.	83	MacMurray, Ill.	94
6. Trinity U., Tex.	100	St. Lawrence U.	100				
		U. of Utah	100				
E—Percent of Married Graduates With at Least One Child							
1. Ore. State	96	Kalamazoo	100	Montana State	100	N. E. Mo. St. T.	100
2. Wash. & Jefferson	95	Allegheny, Pa.	95	*C. of New Rochelle	93	Furman U., S. C.	100
3. Furman U., S. C.	93	U. of Vt.	95	*Sweet Briar, Va.	90	U. of Utah	93
4. U. of Idaho	92	U. of Utah	95	*N. J. C. for W.	89	Allegheny, Pa.	89
5. Allegheny, Pa.	90	*Furman U., S. C.	91	*Vassar	89	St. Olaf, Minn.	88

*Colleges with 80 per cent or more of the graduates with known address reporting.
†Results for women of 1922 are calculated from the address list, i.e. from those listed as "Mrs.". All other ratios are calculated from the number of graduates who replied to the questionnaires. Also see footnote on page 359.

each married woman. The two sexes are closely similar, too, when the purposely or unavoidably childless are omitted. The families of those who had at least one child number 2.21 children for the men and 2.23 for the women.

It is obvious that the married fertile graduates are far from equalling their pioneer forebears and that they are using only a small part of their potential reproductive capacity. All the evidence shows that they are intentionally limiting their families to an extreme degree.

Scores of Individual Colleges

A comparison of individual colleges shows Montana State College to lead the 1922 male graduates with an average of 2.31 children per reporting graduate. Yale reports 2.03; Dartmouth, 1.93; Wesleyan, 1.79; and Harvard only 1.57. Sweet Briar, in Virginia, is outstanding among the women's colleges for 1922, having an average of 2.19 children per graduate. Vassar averages 1.77; Bryn Mawr, 1.42; Wellesley, 1.38 and Mt. Holyoke, 1.10.

Both the men and women of the class of 1921 from the University of Utah reported more children than any other college. The men averaged 3.05 children apiece and the women, 3.12. Amherst, 1921, reported 1.88 children; Princeton, 1.71; Cornell men, 1.66; Harvard, 1.63; Dartmouth, 1.60 and Wesleyan, 1.57. The 1921 women average 1.70 offspring for Vassar; 1.52 for Wellesley; 1.51 for Smith and 1.30 for Simmons.

The Winners

Although the birthrates have been seriously low in all colleges studied, it is noteworthy that the alumni of some colleges have done very much better than others. There seems to be no consistent pattern in this difference, though further study may elicit one. A very hopeful avenue of approach would be to explore the intellectual-emotional reasons for these differences. Today's students and the alumni of these colleges will be especially interested in the intercollegiate comparisons. In Table I are listed the five* who contributed the most to the nation's future, in each of the following categories:

A. Children per graduate
B. Children per married graduate
C. Children per graduate with any children
D. Per cent of graduates who married
E. Per cent of married graduates with at least one child

II. WHY IS THE COLLEGE BIRTHRATE SO LOW?

We have every reason to believe that the graduates of these colleges are a representative sample of all college alumni in our population. The conclusion is therefore inescapable that the more intelligent citizens of our country are having only enough children to insure hardly more than 75 per cent replacement in the next generation. This is doubly unfortunate because of two related factors: this group has been selected on the basis of performance in a quality considerably mediated by heredity and they are in other respects qualified to be among America's best parents. For the sake of our nation's future intelligence it is urgently necessary that they and we—all the citizens of the United States—should realize the implications of this deficit so that steps can be taken somehow to redress the reproductive balance.

No single major factor seems to be responsible for the present birth differential situation. Some of the important motivations are highly subjective matters of personal feeling and opinion. Others lie in the field of economics and sociology. The following discussion reviews the factors which seem to be of importance in this connection.

The High Cost of Children

For a person who has learned to plan, as college graduates can hardly escape

*In category D more than five men's colleges reported 100 per cent of graduates married. All these hundred percenters are included in the table.

doing, the cost of a child represents an obvious and a considerable addition to the budget, even though it will be paid over a period of years. The January, 1944, *Statistical Bulletin* of the Metropolitan Life Insurance Co. finds the total cost of raising a child to the age of 18 for a family with an income between $5,000 and $10,000 to be $20,785, at the price levels of 1935-36. The current inflation adds materially to this cost.

Then, too, a young college graduate is apt to combine a low initial income with high standards of family expenditures for food, clothing and for home building. There may be a strong temptation to delay becoming a parent until there is assurance that the child—one hardly dares say the *children*—can be given "everything," including the 16 years of education which the parents enjoyed. A large part of excessive family limitation comes from such easily understandable apprehension on the part of prospective parents of their needs and of the needs of their children.

The state and society do very little to encourage large families among the middle-income groups. Tax exemptions allowed for children balance only a small part of the annual cost of raising a child. The present exemption of $500 means a reduction in tax of around $100, which will hardly keep even a baby for a year. Like all other "baby bonuses," tax exemptions provide much less incentive at the economic level to which the college graduate aspires than they do for the less intelligent and less educated group. And it is in this middle-bracket income group that the costs of medical and dental care fall the heaviest.

A eugenically valuable revision of our income-taxing procedures might be based on a recognition of the fact that the income of the entire family is usually received by the wage-earning father. Since the present surtax structure is based on increasing rates for a larger income, it would seem logical and equitable to divide the total income of the family by the number of persons in it, before applying these increasing tax rates. Such an equalization would differ from baby bonuses by making the tax reduction per child greater with higher incomes.

Career Versus Marriage

Many men graduating from college today enter the business world with the feeling that their primary mission is to earn prestige and power against competition. Because children may interfere with the attainment of such goals, they tend to be relegated to, at least, a secondary place in the value hierarchy. As time passes the other imperatives replace children and in the end the score is one child—or frequently none.

Some women's colleges instill an attitude in their students which makes them feel that their talents will be wasted as mere housewives. As a result, many graduates, even if they do not follow a career to the extent of spinsterhood or childless homes, strictly limit their families in order to continue intellectual pursuits and part-time or volunteer jobs.

Conflicting Demands

From many viewpoints the home and family appear in our modern society to be much less a center of married life than they were a few generations ago. The Industrial Revolution marked the beginning of the trend away from the home as the pivot of business, intellectual, and recreational life, where children were ardently desired and contributed at an early age to the family economy. The trend toward urbanization has brought smaller homes, with financial, educational and recreational centers outside them. As a result, children have become an increasing economic burden and thus less desirable because they contribute less to the family economy, their education costs more, and their parents' freedom for entertainment is limited. The resulting loss of marital and familial happiness for those who are able to provide for children but who forego the joys of parenthood is all too obvious.

Shifting Survival Patterns

In order to maintain the species, primitive man had to have a birth rate far higher than is necessary at the present time. The average life expectancy must have been considerably less than thirty years and perhaps half the children died before the age of ten. Under such conditions a high birthrate was necessary to insure the survival of the race. In the modern western nations with an expectancy of life of more than 60 years, it would be a catastrophe to maintain a primitive birthrate. With modern death rates and uncontroled births, a single couple could populate the world in less than 700 years and in a thousand years there literally would not be standing room for all on the surface of the earth.

Two centuries ago, when Yale's graduates were contributing five surviving children each, the high mortality among the children of the less intelligent allowed a smaller proportion of that group to grow up and reproduce. Today modern medicine has reduced the death rates of all groups, but only among the intelligent and competent is the birthrate low. To be truly democratic, all groups should contribute proportionally to the reproduction of the race. Those intellectually and financially able to rear large families should do so. The burden of many children should not be put on those least able and poorly prepared to raise them.

The Opportunity of Public Health

The dramatic lessening of mortality rates in recent decades is to be credited to the effective organization of public health programs, and to the wide dissemination of medical discoveries through clinics. If this is not to prove to be a doubtful blessing in the long run, the public health movement must finish the job it has so magnificently begun. Modern medical methods will eventually have to deal with primitive birthrates in all sectors of the population as effectively as they have done with primitive death rates. This goal is not impossibly difficult to achieve.

Social Mobility and Heredity

Social mobility, the ability for individuals and families to move up or down in the economic and educational scale, is one of the basic qualities of our democracy of which we are justly proud. It has much of immediate value for the best use of our intelligence. From the mingling of hereditary qualities, the children in any family will usually vary above or below the average intelligence of their parents, tending generally toward the parental mean. Social mobility makes it possible for those who inherit the best intelligence and who profit most from their environment, to accomplish more for the nation.

Eventually, however, with the passage of time and with an equalization of opportunity, social mobility may have an adverse effect on our genetic heritage. If those inheriting greater intelligence adopt, as they move up the educational scale, the small family pattern found among college graduates, they also will tend to have fewer and fewer children. Then, like milk from which the cream is skimmed, only the poorest heredity will be carried on in any quantity.

At present the tendency toward genetic deterioration is lessened by the fact that many with excellent but unexpressed gene potentialities, lack educational advantages, and therefore have families large enough to replace themselves. Social mobility is a force that can be either beneficial or destructive depending on the total content in which it operates. It could be disastrous if the present birth differential continues, for even a few generations.

Parental Instinct will Partially Compensate

The extensive use of birth control which our studies have indicated may bring with it a ray of hope. Among any group to which birth control is generally available so that the children are born by choice rather than by chance, parental interest will become an increasingly im-

portant selective factor. Alexander Graham Bell in a very important but little noticed article pointed out a quarter of a century ago[12] that as births become increasingly a matter of deliberate volition, an increasing proportion of children will be born to those who really want them. Because these children will tend to inherit the strong parental instinct of their parents each succeeding generation should necessarily possess more of this attribute.

This selective force of birth control is now most strongly operative among the intelligent and the educated, consequently we may see in this component of the population a gradual increase in the parental instinct in future generations. This process will be slow, perhaps too slow to avoid engulfment of plus-genes for intelligence by the more rapidly multiplying children-by-chance group. The obvious expedient to give such selective forces time to act would be to reduce the multiplication of the latter group by a democratization of the means whereby the intelligent and educated have held their reproduction in check.

Shrinking Families of Thinking People

The underlying purpose of these studies has been not only to collect the information regarding the shrinking families of the intelligent, but to bring the facts to the attention of precisely those people whose decisions determine the reproductive score of all the classes of all the colleges. Since the two principal causes of the deficit of children seem to be economic and psychological, as described, there are two specific avenues for amelioration: 1) making our tax structure more equitable with inducements to parents proportional to their income, and 2) educating the potentially good parents in the value and desirability of their children.

That birth differentials can be changed has been demonstrated in Sweden. There an intensive campaign to encourage an equalization of the birthrate has resulted in a reversel of the differential in Stockholm where the educated and well-to-do have the largest families.[12] This is positive eugenics transformed into the beneficial reality that Galton dreamed of. Let us hope that we can achieve it here before it is too late.

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BREEDING STRAWBERRIES FOR VITAMIN C

GEORGE M. DARROW, MARGUERITE S. WILCOX, D. H. SCOTT AND MARGARET C. HUTCHINS*

SLATE and Robinson[4] in New York recently obtained the ascorbic acid (vitamin C) contents of 220 selected strawberry seedlings from 30 different crosses (excluding reciprocals). The highest value was 98 mg. and the lowest 33 mg. per 100 gm. of fresh tissue. The variation was so great among the selections within progenies that no one cross could be said to be superior to any other for producing seedlings with high values.

In 1947, at Beltsville, Maryland, it was possible to test 273 seedlings from six different crosses. Because of severe frosts, the amount of fruit available was small. The results have, however, proved to be significant.

US-2153 [261 × 613 (Campbell × Rossiguol)] was used as a parent because it had the highest ascorbic acid value of the selections and varieties at Beltsville, and Oregon-1629 (Corvallis × Fairfax) was used because of its high value in Oregon. For other parents Fairpeake was used for its high, Midland for its medium, and Aberdeen for its low value. The cross US-3270 (Redheart selfed) × Howard 17 (*Premier*) was used as a random progeny in adjacent rows. The ascorbic acid content of US-3270 is unknown, while that of Howard 17 was 63 mg. in 1946 at Beltsville and was 54 mg. per 100 gm. in 1945 at Geneva, N. Y. The seedlings were grown in hills with all runners removed. This allowed relatively more light to reach the berries than when the matted row is used and may help to account for the relatively high ascorbic acid content of the berries. Also the season was nearly two weeks late, hence the days were slightly longer than for the usual strawberry season at Beltsville.

Harvesting of berries began at 7:00 a.m. Eastern Standard Time and continued until the samples for that day were finished, usually about 1:00 p.m. The samples were analyzed within two hours after picking. Each seedling was sampled at two different dates, usually four to five days apart and plants with high readings were sampled at three or four dates. In the 672 samples, 3,692 berries were used. The number of berries per sample ranged from one to 23, with an average of 5.49. The average weight of samples was 17.8 gm. Whole berries were used when the weight of the sample was less than 25 gm., otherwise sections of the tissues were cut lengthwise from the berries to make up the required weight. The tissue was macerated with eight times its weight of 0.4 per cent solution of oxalic acid in a Waring Blendor. Using Loeffler & Ponting's method[3] the ascorbic acid content of the extract was determined in an Evelyn photoelectric colorimeter with compensation for color due to plant pigments. All results are reported on fresh-weight basis.

Since the ascorbic acid content of the fruit is correlated with light intensity and duration and with temperature[2], data for these three factors were surveyed. Daily mean temperatures (average of maximum and minimum) ranged from 69.5° to 76.9° F. for the seven-day periods preceding picking dates. Daily sunshine duration for the seven-day periods ranged from 58.4 to 76.3 per cent of the

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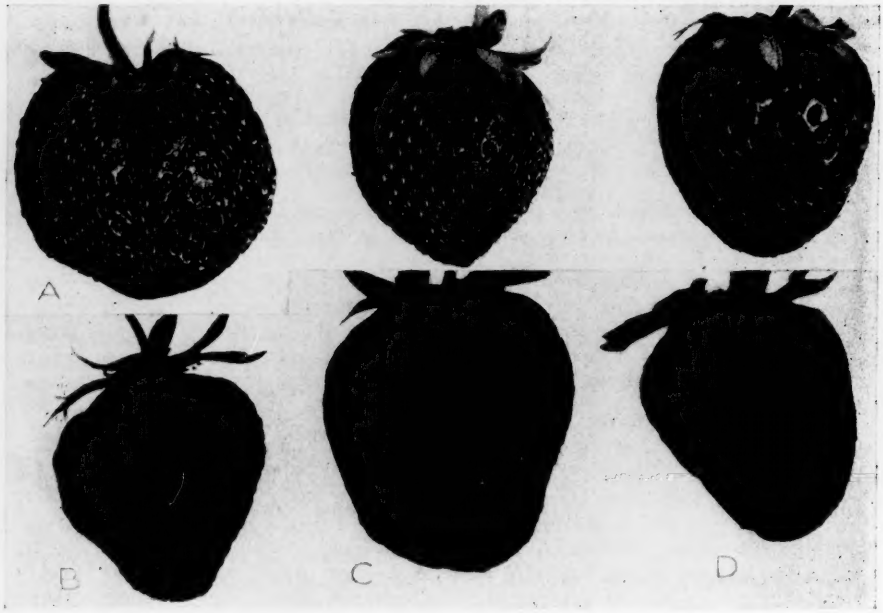

BERRIES OF VARIETIES USED IN TESTS
Figure 2

A—Three berries of the Fairpeake variety which in tests averaged a Vitamin C content of 90 milligrams per 100 grams of fruit. Below is shown a parent-hybrid comparison: *B*—Blakemore; *C*—Fairmore; *D*—Fairfax. The Fairmore variety, a selection from a cross of Blakemore × Fairfax, shows the highest ascorbic acid content in the South.

possible hours. The normal sunshine for the area for May and June is 61 per cent of that possible, so the averages from June 9 to June 20 were above the normal. The periods with high percentages of sunshine, from June 9 to June 13 (69 to 76 per cent) and June 16 to 18 (67 to 70 per cent), should show high ascorbic acid content.

The four parent varieties, used for comparison, were sampled at two dates and these happened to coincide with high seasonal values. In addition, Blakemore and Fairpeake were sampled for eight successive pickings. For these eight pickings Fairpeake averaged 81 mg. and Blakemore 67 mg. per 100 gm. However, for the early part of the season, June 10 to 14, Fairpeake averaged 90 mg. and Blakemore 68 mg.; but for four pickings, June 16 to 20, Fairpeake averaged only 73 mg., and for two pickings, June 16 and 18, Blakemore averaged 63 mg. per 100 gm. Possibly low percentage of sunshine for June 13, 14, and 18 was effective in reducing the ascorbic acid content for this latter period.

The ascorbic acid values for the crosses and for the available parents are given in Table I. It is apparent that seedlings of two high × high crosses (US-2153 × Fairpeake and US-2153 × Oregon-1629) averaged considerably above the high × low (US-2153 × Aberdeen) cross. It should be noted that the average value for the US-2153 × Oregon-1629 cross was considerably higher than that for the US-2153 × Fairpeake cross. Oregon-1629 seems to have genetically, as well as actually, a higher ascorbic acid value than Fairpeake. Though the population of the US-2153 × Midland cross is small, the ascorbic acid content of the seedlings indicates that Midland genetically has

nearly as high a value as Fairpeake. The 20 seedlings of US-3270 × Howard 17 (*Premier*) show a very great spread of ascorbic acid values, both lower and higher than the US-2153 × Aberdeen cross with its four times the number of seedlings.

It is evident that within these various crosses seedlings that might be selected for commercial qualities might have ascorbic acid values either much lower than those of the low parent or much higher than those of the high parent. However, from these tests it appears feasible to breed for high ascorbic acid content of strawberries, and by breeding to increase greatly the already high values in the strawberry.

TABLE I. Six strawberry crosses with percentage of seedlings in each ascorbic acid class, compared with three varieties and a selection used as parents.

	Number	Mg. ascorbic acid per 100 gm. fresh tissue					
	of	30-49	50-69	70-89	90-109	110-129	Average-S.E.
Crosses	Seedlings	%	%	%	%	%	
US-2153 × Aberdeen	88	6	45	42	7	0	69 ± 1.3
US-2153 × Fairpeake[1]	93	2	28	46	23	1	78 ± 1.4
US-2153 × Oreg.-1629[2]	38	0	8	39	39	13	90 ± 2.7
US-2153 × Midland	27	0	41	41	11	7	75 ± 2.9
Oreg.-1629 × Midland	7	0	43	57	0	0	71 ± 4.6
US-3270 × Howard 17[3]	20	25	25	40	5	5	66 ± 4.7
Varieties	Berries						
Aberdeen	87						50 ± 1.5
Fairpeake	119						90 ± 1.5
Midland	149						86 ± 1.9
US-2153	59						103 ± 1.9

[1] Includes reciprocal cross.
[2] Ascorbic acid content 96 mg. per 100 gm. in 1943.
[3] Ascorbic acid content 63 mg. per 100 gm. in 1946.

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TONGUE CURLING

An article entitled *Genetics* which appeared in *Life* (March 17, 1947) aroused our interest in the evidently heritable character of tongue curling. The author of that article stated that approximately 67 per cent of women and 60 per cent of men are tongue curlers, although the number of people tested was not stated in the article.

Our investigations of tongue curling were made with 529 women students of Rosary College and 480 men students of Loyola University (Chicago). Of the women, 379 are curlers and 150 are non-curlers; that is to say, 71.7 per cent are positive and 28.3 per cent are negative for this character. Of the 480 men, 315 are curlers, while 165 are non-curlers. Here there are 65.62 per cent curlers and 34.38 per cent who are non-curlers.

Since individuals are either definitely curlers or definitely non-curlers, it seems that tongue curling is inherited as a simple character.

Our experience in making these tests was not without some difficulty. Many persons, and probably more among men, are quite reserved when it is a matter of having their tongues observed. Such persons may be persuaded to extend their lingual appendages only after they are assured that tongue curling is not a freak characteristic and that probably the majority of normal people can curl their tongues. Even then they rather reluctantly push the tongue out only far enough to rest it on the lower lip; and at the slightest provocation they will usually withdraw it so quickly that one cannot be certain whether they are actually non-curlers or curlers; at least a

few of these had to be recorded as non-curlers. It is possible, therefore, that in these data the higher percentage of non-curlers among the men might be owing to inaccurate classification caused by the shyness of certain subjects.

We also tested the members of several families for this trait. In one family in which the father is a curler and the mother a non-curler, their only living child (a son) is a curler. The son's wife is also a curler. Of their three children (one daughter and two sons) the daughter and one son are curlers. In another family in which both the mother and father are negative for tongue curling their four children (two boys and two girls) are also all negative. In a fourth family, the mother and father are both curlers, as are also all of their four children (three sons and one daughter).

Summary and Conclusions

1. There seems to be no reliable indication of sex-linked or even sex-influenced inheritance in tongue curling.

2. The ratio of curlers to non-curlers among the women in this study is approximately 72 per cent to 28 per cent. Among the men the percentage of curlers to non-curlers is approximately 66 per cent to 34 per cent.

3. Evidence favors the conclusion that tongue curling is inherited as a simple dominant character and the frequency of the gene for tongue curling approximates that of the frequency of the gene for the ability to taste PTC.

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HOW MANY a's IN AARDVARK?

IT is hard to understand who reads such books as these.* Certainly not scientists. It must be that there is a species of spectator scientist that is akin to New York's subway alumni, whose enthusiastic and loyal support may be counted on regardless of whose pennant is waving overhead.

This hypothetical spectator scientist—and he must exist because these books seem to come out with regularity and indeed with a certain uniformity—is interested in everything. Which is to say he is interested in anything, just so it be "science." It may well be asked: Is this necessarily a bad thing? And, assuming that the answer is a thundering negative, the query may be further pursued: Granted that such indiscriminate scientific curiosity has a legitimate right to seek illumination in popular exposition, are the two specimens before us worthy and adequate to the purpose?

The manner of compilation of the two books may guide us toward an opinion. (It is characteristic of this genre of book, that they are almost always compiled, almost never specifically written, for their final format.) The *Science Year Book of 1947* is the sixth of an annual series, composed of science articles culled from the popular magazines, such as *Collier's, Scientific American, Saturday Evening Post,* etc. Each of the 28 "chapters," with one exception, consists of such an article. These chapters are organized in five parts. Scientific endeavor in the year 1946 (although the label on this marketwise package is date-stamped 1947, the product was actually turned out the year previously) as codified in these popularized annals, is accounted for by five catch-all categories: "Physics and Chemistry," "Medical Research," "Agriculture," "Aviation," and "Other Sciences." Despite the neatness of this rather journalistic classification, better than a third of the contents have a homogeneity of source that lies athwart the editorial

**Science Year Book of 1917.* Edited by J. D. Ratcliff. Doubleday and Company, New York, 1947. $2.50.
The Scientists Speak. Edited by Warren Weaver. Boni and Gaer. New York, 1947. $3.75.

fences. These articles, which might better be collected under the heading "War Surplus," are exact duplicates of those slick squibs we have been reading in the Sunday supplements for too long now, about loran, and floating seadromes, and DDT, and the proximity fuze, and bacterial warfare, etc., ad Armageddon.

Science on the Air

The Scientists Speak has a more respectable pedigree, although it too dishes up second hand a pabulum that had already been spoonfed, via another mass medium, to an even larger audience. Here are collected every precious word uttered during the ten minute intermission of the New York Philharmonic-Symphony broadcasts during the years 1945-6-7. It must be stated that the list of speakers (it hardly seems correct to say writers) reads like the starred listings in *American Men of Science.* Shapley, Waksman, Urey, Oppenheimer, Bridgman, Condon, Yerkes, Stakman, Sinnot, Painter, Beadle, Hooton, Notestein, Compton, Langmuir. . . . Even the layman in the thoughtful final chapter, "A Layman Looks at Science," is no less distinguished a personage than Raymond B. Fosdick, president of the Rockefeller Foundation.

This book can not help but reflect the various excellences of the 81 eminent men who each labored assiduously to distill into ten minutes' worth of basic English the essence of his own special province. As a source book of those two-minute speeches that are the favorite assignments of public speaking teachers, this book must have no peer. But as adult education in science, as Dr. Weaver in his preface sincerely believes it to be, it is, by this reader at least, found wanting. Wanting, not in quantity heaven knows — the spaciousness of its compass might well dismay an encyclopedist — but wanting in selectivity. It gives the blurred effect of a series of snapshots — howsoever excellent each may be — displayed eagerly and endlessly by an enthusiastic host. There *is* offered here a view of genuine science, but so rapidly does each fragmentary glimpse flick by that the sooth-seeker may well recoil in confusion, even perhaps with a slight headache. In a commendable effort to rescue the reader from this dilemma of too much and too miniature, there has been added an appendix which contains, for each contribution, a bibliography of technical works so that the lay reader may stop the kaleidoscope at will, and seriously pursue his interest up the narrow byroads of scholarship, far from the din of popular canned culture.

What Are They?

These two books both fall short of the requirements for a text in adult education. The one, which is solemnly dedicated to its high pedogogical intention, is defeated by the lavishness of its profusion, and perhaps even more by the compression induced by the severely standardized tabloid form which leaves on each little essay the forceps mark of its initial delivery. The other, which makes no pretenses to teach, merits our brief attention only because of its misleading title. It is *not* a yearbook of science; "Crowell-Curtis Yearbook" would more nearly describe it. It is a special edition of a popular magazine,—from which all but "science" articles have been excluded,—put up in hard covers. At best it will provide a conversational gambit at the dinner table. *The Scientists Speak* will probably serve a yet more sinister purpose. From the air waves whither it was first cast, it will return redoubled. I can hear the quiz programs now:— "The science of heredity is called, — geneology? geometry? geriatics? genetics? . . . that is corRECT, give the little lady her prize copy of The Science Yearbook of 1948" . . . (cheers, huzzahs, pandemonium. Orchestra strikes up spirited folk air, segues into 5 seconds of Beethoven's 9th).

MORTON STARK

THE FRACTION METHOD OF ANALYSIS OF FACTORS

An Aid in Teaching Genetics*

MELVIN D. JONES

MOST authors of modern genetics textbooks present in detail one or more methods of calculating ratios obtained under conditions of independent assortment or factor interaction when F_1 progenies are selfed or crossed. Punnett[2] describes the "Chessboard" method, which is referred to in most texts as the "Punnett Square" or "Checkerboard" method. Jones[1] describes and discusses the "Algebraic" method. Walter[4] illustrates the "Algebraic" and "Branching" methods. Sturtevant and Beadle[3] use the "Checkerboard" and "Branching" systems. These methods are effective in graphically illustrating segregation and recombination when working with monohybrid or dihybrid progenies, but involve too much detail and become too time-consuming when hybrids of greater complexity are studied. The "Fraction" method presented by the author has proved effective as a fast, accurate means of factor analysis in teaching genetics. While it has doubtless been used by many teachers, it appears not to have got into the literature. With only a limited amount of practice, the beginning student is able to solve complex hybrid ratios.

Procedures are outlined for systematically writing all possible phenotypic and genotypic combinations derived from a given cross. These procedures simplify the explanation of the phenomena of independent assortment and factor interaction. The fraction method soon becomes routine to the student and is less time-consuming for the instructor than the Checkerboard, Branching, or Algebraic methods.

It is helpful during the first class recitation to present one or two problems involving monohybrid and dihybrid ratios by the Checkerboard, Algebraic, and Branching methods in order to give the student a graphic picture of gametic segregation and recombination under each system.

The Fraction Method

The student will quickly grasp the fact that under conditions of complete dominance the monohybrid F_2 progeny segregates into 3/4 of the dominant type and 1/4 of the recessive type. It should be demonstrated that the trihybrid or types of greater complexity are merely a group of monohybrids considered simultaneously and that each factor pair segregates on a monohybrid basis into 3/4 dominant and 1/4 recessive types. By having the student use 3/4 for the dominant allel and 1/4 for the recessive allel when both parents entering into a cross are heterozygous for a given factor, he is able to break down the complex hybrid into its many components and to analyze each on a simple monohybrid basis. Once the student has listed all the phenotypic combinations and has set down the fractions of 1/4 or 3/4 for each segregating gene, he merely has to multiply the fractions in each phenotype to find what proportion of the total population is found therein. (See Demonstration 1.)

Demonstration 1.—In the trihybrid cross *AaBbCc* × *AaBbCc* the phenotypic combinations are:

$ABC = 3/4 \times 3/4 \times 3/4 = 27/64$
$ABc = 3/4 \times 3/4 \times 1/4 = 9/64$
$AbC = 3/4 \times 1/4 \times 3/4 = 9/64$
$Abc = 3/4 \times 1/4 \times 1/4 = 3/64$
$aBC = 1/4 \times 3/4 \times 3/4 = 9/64$
$aBc = 1/4 \times 3/4 \times 1/4 = 3/64$
$abC = 1/4 \times 1/4 \times 3/4 = 3/64$
$abc = 1/4 \times 1/4 \times 1/4 = 1/64$

*Contribution from the Department of Agronomy, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma. The author is Assistant Professor of Genetics and Plant Breeding.

If one parent is heterozygous and the other is homozygous recessive for a given factor, the fraction 1/2 is substituted for both 3/4 and 1/4. This is the equivalent of the monohybrid backcross. If both parents are homozygous dominant, homozygous recessive, or one parent homozygous dominant and the other heterozygous for a given factor, the fraction 1/1 is substituted for 3/4 and 1/4. In the latter case all the offspring appear dominant. (See Demonstration 2.)

In this particular cross, factor *A* is segregating 1/2 dominant, 1/2 recessive, factor *B*, 3/4 dominant, 1/4 recessive, and factor *C* which is showing no phenotypic segregation is represented by 1/1. Actually phenotypic segregation is on a dihybrid instead of a trihybrid basis.

Attention has been given to factor analysis under conditions of complete dominance in which segregation of monohybrids is 3/4 dominant and 1/4 recessive. The fraction method works equally well with incomplete dominance. In such case the monohybrid fractions 3/4 and 1/4 become 1/4 dominant, 1/2 intermediate, 1/4 recessive. These fractions are used in the same manner as with complete dominance, the only difference being that the number of phenotypes is three instead of two.

Writing Formulas for Phenotypic Groups

After the student has learned which fractions to use and when to use them, he can quickly and accurately write the genetic formulas for all phenotypes derived from a cross by observing a few simple rules. The number of possible phenotypes resulting from a cross is determined for complete dominance by raising 2 to the *nth* power, in which case "2" represents the possibilities of dominance and recessiveness, and "n" the number of hybrid pairs involved. Writing formulas for phenotypic groups in which incomplete dominance is involved is the same as for genotypic groups since each genotype is a phenotype. (Incomplete dominance is discussed below in the section treating genotypic groups.)

When parents differ with regard to allels, theoretically, one-half of the F_1 gametes will carry the dominant allel and one-half the recessive allel of each gene. In constructing the formula, one-half of the phenotypic combinations for the first gene should show the dominant allel and one-half the recessive allel (Demonstrations 1 and 2). For the second gene, the dominant and recessive allels are alternated twice as frequently as with gene one. For the third gene, the dominant and recessive allels are alternated twice as frequently as with gene two. For each additional gene involved in a cross the dominant and recessive allels are alternated twice as frequently as the preceding gene. To systematize the writing of phenotypes the groups showing the dominant allel of each gene are listed first, followed by the recessive form, until all possible combinations are included. By following this scheme of dichotomy, it is easily possible to write all expected phenotypic combinations.

After formulas for the phenotypes are set down, apply the rules governing the use of fractions to determine the number of individuals in each phenotypic group. The fraction method is applicable to factor analysis even though the ratios may be altered by incomplete dominance, epistasis, inhibitor factors, or other types of factor interaction.

Writing Formulas for Genotypic Groups

It requires much time and effort to write all the genotypic combinations expected from a trihybrid by use of the Checkerboard method and one may become hopelessly lost in attempting to work out the genotypic combinations of complex hybrids by observing the genetic formulas of the parents and attempting to list all genotypic combinations. But even the beginning student of genet-

Demonstration 2.—In the trihybrid cross *AaBbCc* × *aaBbCC* (with only two genes segregating for phenotype) each of the rules for use of fractions is illustrated:

$$ABC = 1/2 \times 3/4 \times 1/1 = 3/8$$
$$AbC = 1/2 \times 1/4 \times 1/1 = 1/8$$
$$aBC = 1/2 \times 3/4 \times 1/1 = 3/8$$
$$abC = 1/2 \times 1/4 \times 1/1 = 1/8$$

ics can analyze genotypically the most complex hybrids by following a few simple rules which have been formulated in connection with the fraction method.

The number of possible genotypes resulting from a cross is determined by raising 3 to the *nth* power, in which case "3" represents the number of possible different breeding groups derived from each factor pair and "n" the number of factor pairs involved. These same facts are applicable in determining the number of phenotypic groups with incomplete dominance in which case each phenotype represents a different breeding group.

Theoretically the zygotes of each hybrid pair will fall into the following three genotypic groups: homozygous dominant, heterozygous, and homozygous recessive.

In constructing the formula, one-third of the genotypes for the first gene should show the homozygous dominant, one-third the heterozygous, and one-third the homozygous recessive condition (Demonstration 3). For the second gene, the three genotypic combinations are alternated three times as frequently as with gene one. For the third gene, the genotypic combinations are alternated three times as frequently as with gene two. This procedure of alternating the genotypic combinations of a gene three times as frequently as with the preceding one, until each gene involved in a cross has been adequately treated, will result in the genetic formula for each genotype appearing. Similar genotypes are added together to give the phenotypic ratio.

The trihybrid example presented in Demonstration 3 shows this method of listing genotypes. Since there are three segregating factors involved, 27 genotypic combinations are possible (3^3). According to the above mentioned rules gene "A" is listed 9 times (one-third of 27) for each the homozygous dominant, heterozygous, and homozygous recessive condition. Gene "B" is alternated three times as frequently as gene "A" and occurs in groups of three homozygous dominant, three heterozygous, and three homozygous recessive for each of the gene "A" groups. The combinations of gene "C" are alternated three times as frequently for each group as gene "B". The number of individuals expected per genotype is determined by multiplying each homozygous factor pair by one and each heterozygous by two, since there are, respectively, one and two different-appearing groups.

Demonstration 3.—Kinds of genotypes and the number of individuals expected in each upon selfing or crossing the trihybrid, *AaBbCc*.

1 AABBCC	2 *Aa*BBCC	1 aaBBCC
2 AABB*Cc*	4 *Aa*BB*Cc*	2 aaBB*Cc*
1 AABBcc	2 *Aa*BBcc	1 aaBBcc
2 AA*Bb*CC	4 *Aa*Bb*CC*	2 aa*Bb*CC
4 AA*Bb*Cc	8 *Aa*Bb*Cc*	4 aa*Bb*Cc
2 AA*Bb*cc	4 *Aa*Bbcc	2 aa*Bb*cc
1 AAbbCC	2 *Aa*bbCC	1 aabbCC
2 AAbb*Cc*	4 *Aa*bb*Cc*	2 aabb*Cc*
1 *AA*bbcc	2 *Aa*bbcc	1 aabbcc

Summary

A fraction method of genetic analysis of independent assortment and factor interaction is presented. As a basic system it is broadly applicable to the analysis of complex as well as simple hybrid ratios under conditions of complete or incomplete dominance, epistasis, inhibitor factors, and other types of factor interaction which may alter normal ratios. The essential features of the method are the same as those of the Checkerboard, Branching, or Algebraic methods, but the speed and simplicity of presentation of genetic material makes the fraction method more desirable for the teacher and the student of genetics. Rules are given for systematically, accurately, and quickly writing all phenotypic and genotypic combinations expected from simple or complex crosses. The application and advantages of the method are discussed.

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CHIMERAL SPORTS OF APPLES

JOHN EINSET, H. WESTON BLASER, AND BARBARA IMHOFE*

THE authors have previously described a "Giant" sport of the Northern Spy apple.[1] This sport was found to be a periclinal chimera, in which the periclines had the diploid and tetraploid chromosome number. Recently five additional large-fruited sports of a generally similar appearance have been found in the apple. All six of these are periclinal chimeras, but of three different types with regard to the relative numbers and locations of diploid and tetraploid cells.

Type 1. The first type is predominantly tetraploid with only a "skin" of diploid tissue. Half of our chimeras fall into this group: the "Large" Wealthy (Stevenson), the "Giant" Wealthy (Loop), and the "Ontario," all of which are described in detail below. These are all sports of diploid varieties. They are nearly wholly tetraploid in all parts of the tree; all internal tissues are composed of cells with 68 chromosomes. Only the epidermis has been found to be diploid, its cells containing 34 chromosomes (Figure 3). These sports breed like tetraploid apples and produce tetraploid seeds following self-pollination.

Type 2. In the second group may be placed the "Giant" Spy, previously described and the Jonathan Sport (Welday). The epidermal as well as subepidermal layers of cells in the stem apices are diploid in these sports. The deeper cell layers are all tetraploid. A study of the distribution of diploid and tetraploid cells in the stem, leaves and flowers of these forms has been made and a complete analysis will be published elsewhere.

Type 3. The sixth periclinal chimera is a "Giant" Rome (Loop) and represents still a third type. This sport is similar to those in the second group but has more diploid cells in its makeup. It may have three layers of diploid cells covering the tetraploid inner portion in the stem tip; in leaves and flowers the amount of tetraploid tissue is very limited. Since sporogenous tissues are derived from the second layer of the apex, the forms representing the last two types breed like diploids and produce diploid seeds following fertilization and embryo formation.

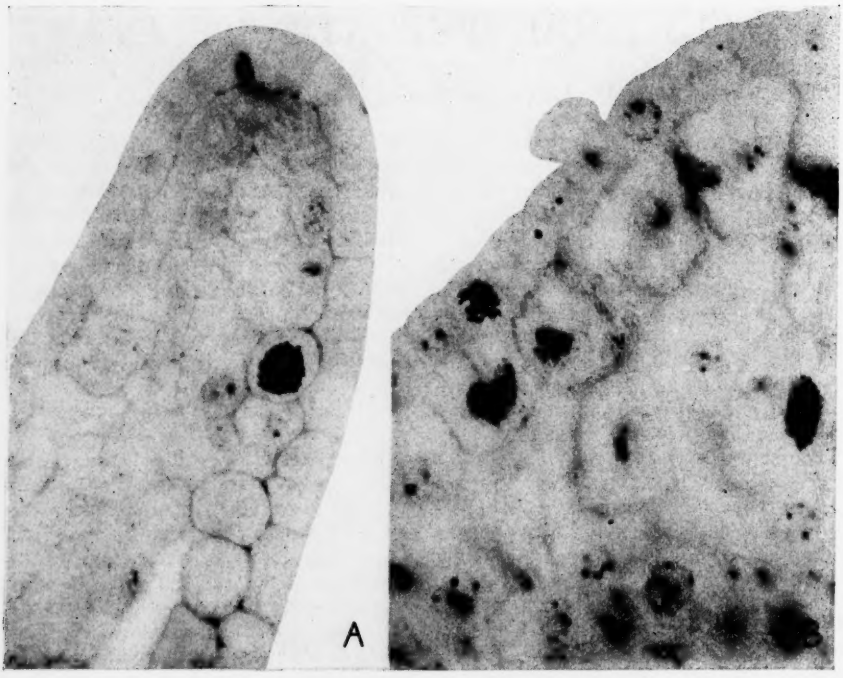
History

The "Large" Wealthy (Stevenson) was found by Mr. J. Roe Stevenson of Cayuga, New York, in an orchard planted in 1919. Only part of a tree produced large fruits. Scions were sent to the Station in the spring of 1938. The sport was top-grafted on seedling rootstock and planted in the orchard in 1940. This sport is a vigorous grower and has had some fruit every year since 1943.

The "Giant" Wealthy (Loop) is growing in a forty-year-old orchard near North East, Pa. Mr. H. S. Loop sent material to the Station in the spring of 1947. On cytological examination this sport was found to be like the other Wealthy sport; the epidermis alone was diploid and all underlying tissues were tetraploid.

A tree which is growing in the Station orchard under the name of Ontario has also been found to be a chimera of type 1, with only the epidermal layer diploid. This tree is budded on seedling roots. The buds came from an Ontario tree acquired by the Station from a local nursery in 1910. Other material of Ontario was obtained in the spring of 1947 from the Vineland Station, Ontario, Canada, from Nova Scotia and from a local grower. Ontario material from these sources was wholly diploid, in agreement with previous findings by Kobel[2] and Nebel[3]. Our Ontario at the Station has the char-

*Journal Paper No. 728, New York State Agricultural Experiment Station, Geneva, N. Y.



DIPLOID-TETRAPLOID CHIMERAS
Figure 3

A—Longitudinal section of young leaf (Ontario sport) showing subepidermal cell with tetraploid complement of chromosomes. *B*—Portion of transverse section of young leaf ("Giant Wealthy," from Loop) showing epidermal cell with diploid chromosome complement and bundle sheath cell of a lateral vein with tetraploid chromosome complement.

acteristics of the variety and it may therefore be assumed that it is a chimeral sport of the true Ontario.

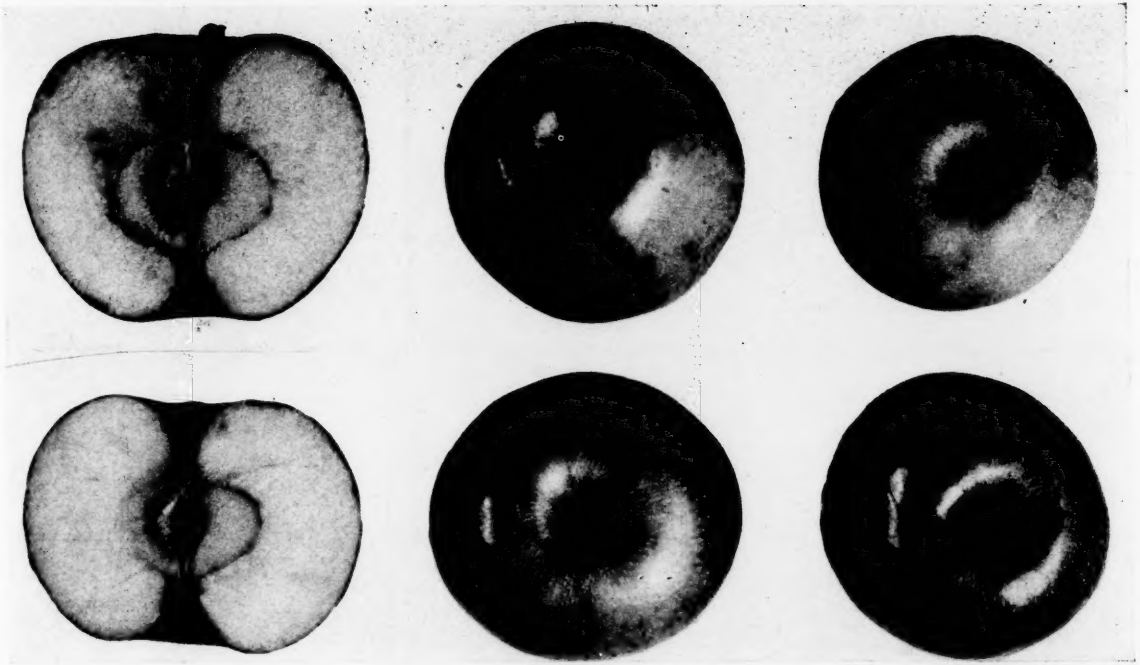
The "Giant" Spy has been described previously by the authors.[1] Scions of this sport were sent to the Station by Mr. H. S. Loop of North East, Pa., in 1931 and a young apple tree was grafted over. Since that time two additional trees have been established on seedling roots. These have also been studied cytologically and are of the same chimeral structure.

Scions of the Jonathan Sport were received in 1932 from Mr. W. S. Welday of Smithfield, Ohio, and a young apple tree in the orchard was top-worked to this sport.

The "Giant" Rome was received by the Station in 1931 from Mr. H. S. Loop of North East, Pa., and a young apple tree in the Station orchard was grafted to this sport. Mr. Loop has two trees of this sport in his orchard. A neighbor, Mr. Phillips, who obtained some of the same lot of trees has several that show the "Giant" characteristics. One of them appears to be only partly "Giant" (Figure 5).

Characteristics of the Sports

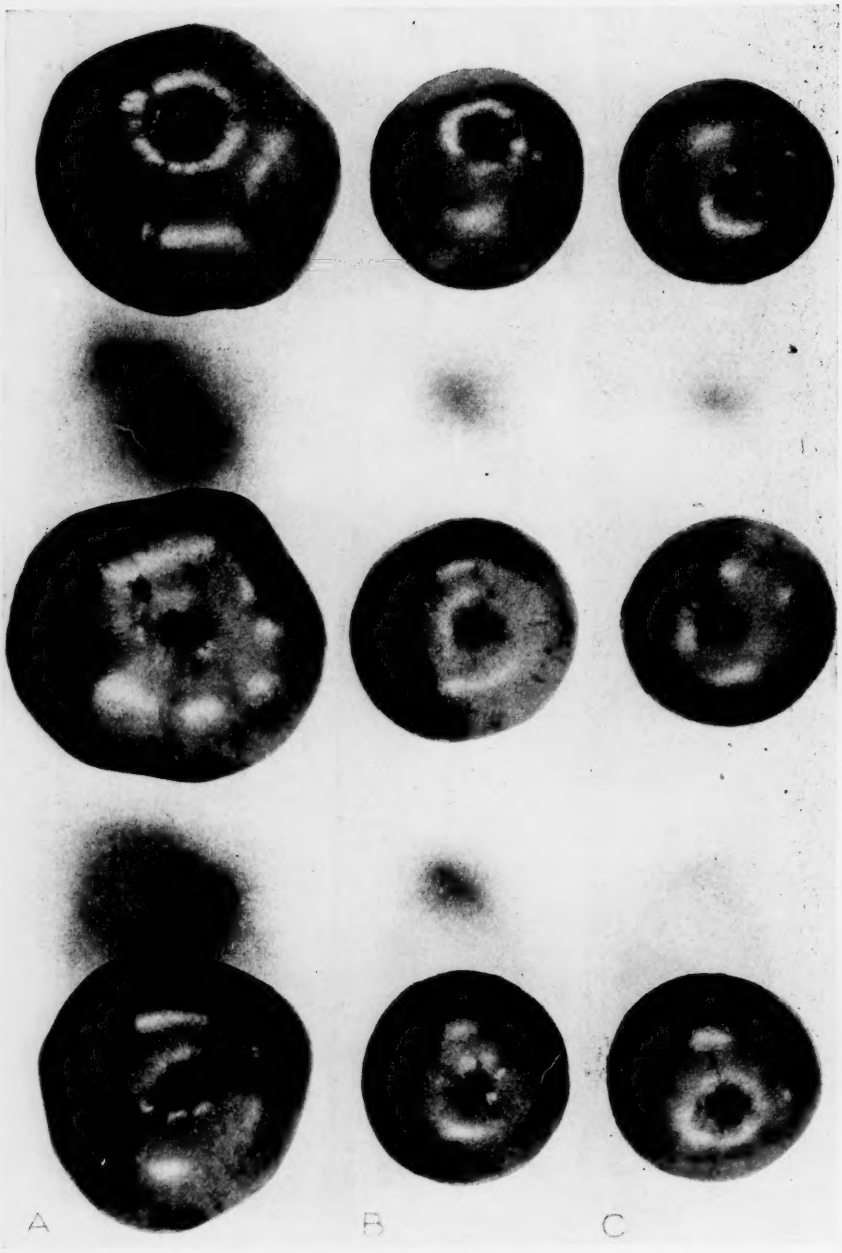
Five of these six sports have been found and sent to the Station as large-fruited or "Giant" forms. An attempt has been made to describe visible differences between the sports and their parent varieties. The Ontario sport has not been included in the comparisons because we are not absolutely sure of its origin and therefore have had no varietal material with which to compare it.



GIANT AND NORMAL WEALTHY APPLES

Figure 4

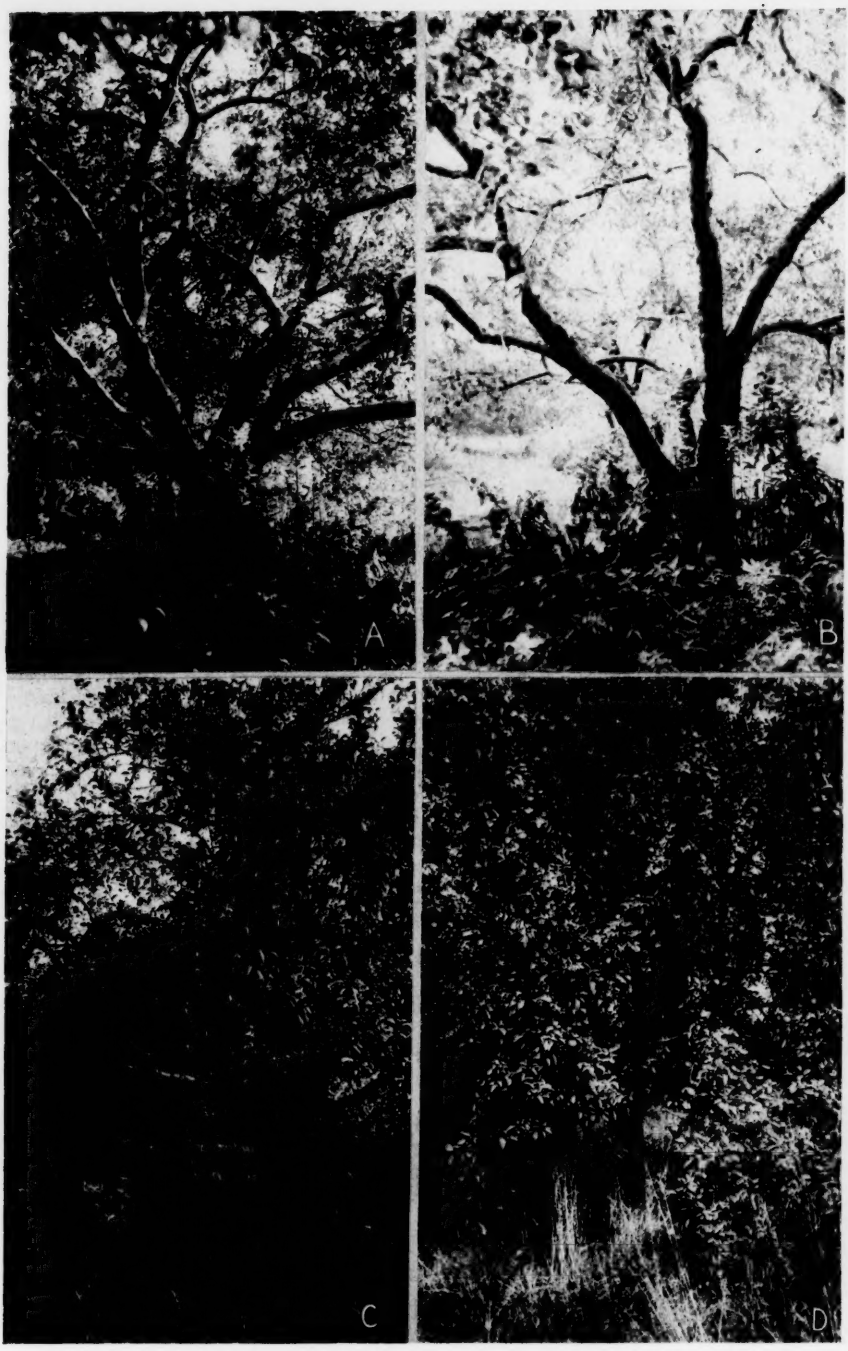
Sectional and top views of fruits of "large" Wealthy (upper row) and of Wealthy (below). There is a consistent difference in shape in the fruits of normal and giant forms.



"GIANT" AND NORMAL APPLES

Figure 5

"Giant" Rome from Phillips' orchard. The three apples on the left were picked from a "Giant" branch and measured 3½-4½ inches in diameter. The apples in the center, measuring 3-3¼ inches, grew on other branches of the same tree. The 3-inch Romes on the right were typical of fruits on an adjoining tree.



"GIANT" TREES ARE MORE SPREADING

Figure 6

A—Tree of "Giant" Wealthy (Loop) as compared with an adjacent tree of Wealthy (*B*). *C*—Tree of "Giant" Rome (Loop) and (*D*) a Rome tree nearby. Notice the more spreading type of growth of the "Giant" forms.

The following paragraphs list the characteristics which differentiate the sports from the parent varieties.

Tree. The sports are all vigorous growers. The "Giant" Wealthy (Loop) appears to be decidedly more vigorous than the mother variety. The Wealthy (Stevenson), and the Ontario also show marked vigor. This observation is of interest because with the exception of the epidermis these trees are wholly tetraploid. The sports of Spy, Jonathan, and Rome with a larger number of diploid cells are about as vigorous as the parent varieties. All the sports tend to have flatter trees than the varieties and the angles of the branches are wider. This characteristic is most striking in the sports of Wealthy (Figure 6, *A* and *B*), Spy, and Rome (Figure 6, *C* and *D*).

Fruiting. The sports bloom at the same time as the varieties and the amount of bloom has generally been about the same. Most of the sports have been nearly but not fully as productive as the comparable variety. The "Giant" Wealthy (Loop) has been fully as productive as Wealthy in the orchard in North East. The "Giant" Spy at the Station has been unproductive but the original tree at North East has been nearly as productive as Northern Spy.

Fruit. All these sports with the exception of the Ontario have been selected as large-fruited forms. However, there are certain differences between the fruits of the sports and the varieties which seem to be more striking than mere size differences. The two Wealthy sports have symmetrical apples, very similar to Wealthy but somewhat larger, more flattened and with a broader basin (Figure 4). The calyx lobes are also broader, fleshier and more noticeable. The sports containing more diploid tissue, namely "Giant" Spy, Jonathan Sport and "Giant" Rome have many of the same characteristics. They all have fruits which are somewhat larger, most strikingly so in Rome (Figure 5), definitely flattened, and with a broader basin. The "Giant" Spy and the Jonathan Sport, classed together as type 2, have fruits that are not as symmetrical in shape as the parents but seldom extremely irregular in contour. The "Giant" Rome fruits are outstanding because of their irregular form as well as their large size under good growing conditions (Figure 5). It is this sport with the least tetraploid tissue and the greatest amount of diploid tissue that appears to differ most in fruit characters from the parental variety.

Leaves and buds. In trees of good vigor the leaves of the sports appear to be rougher, duller and of a darker green color than leaves of the varieties. When the leaves were mixed they could be sorted with 98 per cent accuracy using these characteristics as a basis for separation. The leaves also appear to be somewhat shorter and broader in the sports but measurements of fifty leaves of Giant Spy and Northern Spy gave ratios of length to width that were not significantly different. The petioles of leaves of similar vigor seem to be thicker in the sports, the thickness being greater primarily in the dorsiventral direction. Petioles can be re-sorted when mixed. The buds of the sports appear to be generally broader and more dome-shaped than those of the varieties. However, ranges of measurements overlap in all cases with the exception of the Wealthy and its sports. The buds of the sports were, in this instance, definitely broader at the base than the buds of Wealthy, and could be re-sorted when mixed.

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ODD FAMILIAL P.T.C. REACTION

An Unusual Sensitivity to Phenylthiocarbamide

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WHEN leaflets for testing ability to taste phenylthiocarbamide were first distributed by the American Genetic Association about sixteen years ago, the context[2] invited reports of the tests and stated that "data on familial reactions will be appreciated." This note reports reactions which, it is hoped, will be appreciated more by readers of the JOURNAL OF HEREDITY than they were by the family that experienced them.

For several years the taste-test leaflets have been given to members of the writer's class in heredity and eugenics prior to their departure for the Christmas holidays. The students were asked to take advantage of family gatherings at the festive season to test as many relatives as possible. Over the past seven years this has resulted in reports from about 250 families comprising over 1300 persons. Among them the proportion of non-tasters has been close to the 28-30 per cent found by others[1,6] in larger samples of the U. S. population. A few families were found each year in which neither parent could taste P.T.C. and in these none of the children was a taster. The ratios in other families, whether both parents or only one could taste the substance, also agreed with those previously reported. Each year the tests and the summarization of results have created considerable interest. Most of the class have been premedical students, and therefore interested particularly in human heredity. Their own demonstration that inability to taste P.T.C. is a simple, recessive, autosomal character was good evidence that laws of genetics apply to man just as to yellow mice, single-combed chicks, and other samples of the geneticist's stock-in-trade.

In 1946, one of the class, the daughter of a member of the Cornell faculty, on testing her family after supper found that to both her parents, her two sisters, and herself the paper tasted bitter. The youngest girl, about six years old, went to bed at 8:30 but woke up, sick at the stomach, about 10:00 p.m. As this was an unusual occurrence, a doctor was called, but no other sign of illness or cause for nausea was discovered. P.T.C. was not then incriminated. Next day the child was in normal health.

Small bits of the testing paper were also sent by the student to her maternal aunt and grandfather in a distant city. A day or so later the grandfather telephoned to ask if he had been the victim of a practical joke. It turned out that he and his daughter (the student's aunt) had both tasted the P.T.C. paper after breakfast and had found it bitter. An hour or so later, the grandfather woke up from a nap, sick at the stomach. He was quite sure of the cause, and he could then still taste that bitter material of the test paper. He was somewhat worried, as the experience was unusual for him, and called by telephone to find out what kind of poison he had been given.

On receipt of this news, the similarity to the mysterious nausea of the little girl was immediately noted, and a request for further information was sent forthwith to local P.T.C. headquarters. Fortunately, the writer was then away at A.A.A.S. meetings. By the time of his return, there being no complicating sequellae, the air had cleared somewhat.

No comparable case is known to the writer. The fact that persons who can taste P.T.C. differ greatly in the sensory threshold, or minimum concentration that can be tasted, has been shown by Blakeslee and Fox,[1] Salmon and Blakeslee,[5] Hartmann,[4] and Falconer.[3]

None of these investigators recorded nausea caused by P.T.C. in the amounts used for testing, although some of their subjects must have had far greater doses than the two concerned in this note. (From the unused portion returned, it was calculated that those tested in this family each had used about one-third of a square inch of the test paper. This contained whatever amount of P.T.C. was absorbed during immersion in a 0.5 per cent solution in acetone). Two persons tested by Blakeslee and Fox did become nauseated, but both had taken by mistake many times the proper dosage of the actual crystals. Dr. L. H. Snyder (private communication) writes that he has known people to complain that P.T.C. almost nauseated them, but never to the point of actually vomiting.

It is easy to say that nausea is not unusual and that the occurrence of these two cases in one family is merely a coincidence, but it would be difficult to convince the family concerned with that argument. Obviously, the experiment should be repeated, but, while it is all very well for Haldane to drink dilute hydrochloric acid, or for the writer to gorge himself on chicken said to be loaded with estrogenic hormones, there are limits to the experimentation that one may ask of a six-year-old child and her grandfather.

It is worth noting that neither of these persons became sick at the time of chewing the paper, but that both did so while asleep two or three hours later. It is doubtful if many adult persons tested with P.T.C. have been asleep within a short time thereafter, as most such tests are made during working hours. Could sensitivity be heightened merely by inactivity, by sleeping, or by recumbent posture? Although this last suggestion seems far-fetched, it may be recalled that one genetic character in man is manifested more readily in patients flat on their backs than otherwise (asthma) and that another is suppressed simply by lying down (urobilinuria).

As far as they go, these two cases in one family only suggest that there may be an extreme sensitivity to phenylthiocarbamide and that it may be genetic. They are noted here merely so that other investigators will be encouraged to report similar instances if they occur.

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✦

Postscript on the Diabetes-Non-Tasting Correlation

SEVERAL interesting questions were raised by the correlation between diabetes melitus and inability to taste PTC, as reported by Terry and Segall in the May 1947 issue of this Journal. The authors suggested the possibility that non-tasting diabetics may be genotypic tasters. Can it be that non-tasting in diabetes is non-specific for PTC? Have any tests been made to determine whether a lessening of taste acuity in general accompanies diabetes? Has the possibility been explored that there may be a correlation between non-tasting and insulin? The following reply was received from the senior author.

TO THE EDITOR:

The data from which our paper was written contain no answers, I am sure, to these questions. I am no wiser as to those particulars than I was several years ago when, after testing 36 persons, diabetic and non-diabetic, I saw what I saw, viz., 46 per cent of non-tasters among the diabetics. All I have got, *for sure,* from the present much larger number of observations is assurance that the undertaking was worth while.

I have not inquired how far out of bounds the following ideas may be with

respect to genotype and phenotype; but I have thought that an experiment with alloxan and rabbits, white rats, or dogs, might turn up something new. White rats would be best because of rapid reproduction (and because they were available to me in the Department of Anatomy), dogs best for a better reason, viz., their known susceptibility to diabetes.

I tested a few dogs (and even a few birds!) and found that, with one exception, the dogs showed a strong dislike for PTC. The one exception was a very fat, very old, Cocker Spaniel bitch who is much of the time under a veterinarian's care. She does not object to the taste of any medicine he gives her. She may be diabetic for all I know.

Blakeslee *et al* (at Smith) made a study on threshold recognition of the taste of PTC; but, of course, without any thought of diabetes.

Alloxan diabetes, they say, may be controlled indefinitely by insulin. If so, experiments could be devised.

There are exogenous factors in the incidence of human diabetes. The Metropolitan Life Insurance Company mentions some of these in their pamphlet on diabetes and undertakes to give advice.

In a 1945 number of the *New England Medical Journal*, (233[13]:376-78), Dr. H. C. Miller presents some evidence for a "prediabetic state" operative, in his cases, well before the appearance of the disease but not discovered until long thereafter. Perhaps PTC might help to identify such "prediabetics." Dr. Miller's data consist in the following mortality rates for "prediabetic" and non-diabetic mothers at childbirth.

Status of mother	Number of mothers	Number of births	Number of infant deaths	Mortality rate—%
Non-diabetic	59	253	5	2.0
"Prediabetic"	57	264	22	8.3

The difference is highly significant statistically. All of the 57 "prediabetic" mothers were non-diabetic at the time of delivery. All 57, it was discovered, developed diabetes later, but none before 40 years old.

Dr. Best, of Toronto, has a chapter in a new book entitled, *Currents in Biochemical Research,* in which he says (page 431) in speaking of the possible prophylactic use of insulin: "application will not be easy until the potential human diabetic can be recognized much earlier than is possible at present." It is barely possible that PTC or the like might be of some service here.

There is a diabetic woman here who says she can tell by a bitter taste in her mouth when she must take her shot of insulin. Neither just before taking the insulin nor at any time before or after does she detect the taste of PTC.

It looks as if the Negroes may constitute a special case.

M. C. Terry, M.D.

P.P.S. As to the possibility that insulin therapy (or diabetes itself) may change a taster to a non-taster, we may have to wait until the youngest diabetic known to be a taster is old enough to have the trophic ulcers of the disease. I have but one case to the point—a patient who was a taster—and so remains.

The following was contributed by a physiologist who knows some of them: "There are diabetics who do not take insulin; if they were tested they would show a low I.Q." Projection: Insulin is taken now by all diabetics smart enough to get it. Wider use would tend to preserve an unwanted mutant gene for susceptibility to diabetes, to lower I.Q. and to more diabetes!

It isn't insulin that makes smart diabetics smart, it keeps them smart longer. If any controllable exogenous factor in the causation of diabetes is found,* the use of insulin may be expected to raise the I.Q. and decrease diabetes! Therefore: On with surveys, experiment, and theory.

M.C.T.

*See the control chart for poliomyelitis in California (Rich and Terry: *Public Health Reports* Vol. 61, No. 42. 1946). Also the report on diabetes in a New England town, *J.A.M.A.* Sept. 27, 1947. There are two other recent articles of some relevancy: 1) C. W. Jungablut: *Annals of Internal Medicine* 26:1, 1947, and 2) M. B. Frank: *Proc. Soc. Exp. Biol. and Med.* 62:1, p. 17, 1947. The first correlates blood group A_2 with paralytic poliomyelitis, and the second correlates it with filariasis.

NOTE ON CERTAIN MENDELIAN RATIOS IN MINK

LARRY MOORE AND CLYDE E. KEELER
Mink Rancher, Suamico, Wisconsin, and Georgia State College for Women, Milledgeville, respectively

SOME criticism has come to our attention concerning the statement made by Castle and Moore* that Blufrost (*Ff*) or Silver Sable as it is sometimes called, is due to a mendelian dominant gene, possibly lethal in homozygous form. Specifically the criticism stated that sufficient data were not available to establish its nature as due to a mendelian dominant gene.

We would like to present the following in support of this hypothesis:

(1) Blufrost (*Ff*) × Blufrost (*Ff*) produced 19 Blufrost (*Ff*) and 10 normal Dark (*ff*) with a litter average of 3.65.

(2) Blufrost (*Ff*) ♀ × normal Dark (*ff*) ♂ produced 78 Blufrost (*Ff*) and 80 Dark (*ff*) with an average litter size of 5.27.

(3) Blufrost (*Ff*) ♂ × normal Dark (*ff*) ♀ produced 345 Blufrost and 325 Dark with an average litter size of 5.11.

If we examine cross (1) we obtain the following statistics: n = 29, deviation from 2:1 ratio = 0.33, standard error of the ratio = 2.55, deviation ÷ standard error = .129. A deviation of this size from ideal value is to be expected in more than 84.14 per cent of repetitions of similar sampling. Hence the probability is very high that all Blufrost individuals are of the *Ff* genotype. Normal litter size is about 5.20. Blufrost litter size is 3.65 which represents a reduction of 30 per cent. From this cross we expect a loss of 25 per cent if homozygous Bluefrost (*FF*) is lethal, as was suggested by Castle and Moore.

When we examine crosses (2) and (3) which are reciprocal, we see that no sex linkage is involved. Hence these two crosses may be combined for statistical examination: n = 828, deviation from 1:1 ratio = 9, standard error of the ratio = 14.4, deviation ÷ standard error = 0.625. Deviations from expectancy would be as great as this in 54.86 per cent of similar samples. We do not conclude that a mendelian gene is not functioning unless deviation ÷ standard error => 2.000.

It may be worth while putting on record certain data on Royal Kohinur (*Kk*) which is both viable and distinguishable in the homozygote (*KK*).

(4) Kohinur (*Kk*) × Kohinur (*Kk*) produced 37 homozygous Kohinur, 73 heterozygous Kohinur, and 34 normal Dark. Average litter size = 4.80.

(5) Kohinur ♀ × Dark ♂ produced 41 Kohinur and 37 Dark. Average litter size = 4.60.

(6) Kohinur ♂ × Dark ♀ produced 627 Kohinur and 593 Dark. Average litter size = 5.3.

We may consider this 1:2:1 ratio in cross (4) on the basis of a 3:1 ratio: n = 144, deviation from 3:1 ratio = 2.00, standard error of the ratio = 5.19, deviation ÷ standard error = 0.38. A deviation of this size will be expected to occur between 68.92 per cent and 84.14 per cent of repetitions of the experiment employing samples of the same size.

Because no sex linkage is indicated the reciprocal crosses (5) and (6) may be combined for statistical examination: n = 1298, deviation from 1:1 ratio = 19, standard error of ratio = 18.01, deviation ÷ standard error = 1.05. Such a deviation is expected in 31.74 per cent of repetitions of the same experiment.

We believe that the data considered above present ample evidence that both Blufrost (Silver Sable) and Royal Kohinur coat variations of mink are due to one dominant gene apiece, that homozygous Kohinur (*KK*) has normal viability, and that homozygous Blufrost (*FF*) is lethal.

*CASTLE, W. E., and LARRY MOORE. Mutations of Mink Under Domestication. *Jour. Hered.* 37:137-145. 1946.

MUTANT WHITE MICE

A New Dominant Autosomal Mutant Affecting Coat Color in *Mus musculus**

ARNOLD B. GROBMAN† AND DONALD R. CHARLES
University of Rochester

AMONG the offspring of a mating, *dba* ♂ (Little), by C57 Black ♀, was one female of coat color quite similar to the phenotype of *ddB-* although this constitution was not expected since the C57 ♀ was presumed homozygous for *D*. Twenty-six siblings of the exceptional female were intense colored (*D-*).

This female carried a mutant gene for which we propose the name, *White*, symbol, *Wh*. Mice heterozygous for *Wh* resemble, but are somewhat lighter than, dilute, *dd*, mice. *WhWh* animals are indistinguishable by color from true albinos, *cc*. The results of various crosses involving *Wh* are summarized in Table I.

On a black, *B-*, background, the descending order of color intensity among animals with combinations of white, *Wh*, and dilute, *d*, is: *D-whwh*, black; *ddwhwh*, dark gray or "blue"; *D-Whwh*, gray; *ddwhwh*, pastel gray; *--WhWh*, white.

The seriation is similar in *bb*. Brown mice with the constitution *ddWhwh* are a very delicate silver color and appear lighter than the corresponding blacks.

To express the effects of *Wh* in more concrete fashion, individual hairs were mounted and studied by Miss Ann Hoag of this laboratory. The hairs were taken from the mid-dorsal region. Over a period of three or four days they were passed progressively through increasing concentrations of xylol in 95 per cent alcohol, (beginning with 10% xylol; then 25%, 50%, 76%, and finally two changes of 100% xylol). Properly cleared hairs were free of air spaces which obscure the cortical and medullary pigment in untreated hairs. The hairs were mounted in balsam on slides. In order to obtain a measurement of the width of the medullary pigment bands, the slides were placed in a microprojector. Tracings were made of 100 micron lengths of the hairs. The section involved was always the 100 microns proximal to the second bend from the distal tip of a zig-zag hair. On the tracing sheets a straight line was drawn through the approximate center of the row of medullary pigment bands and

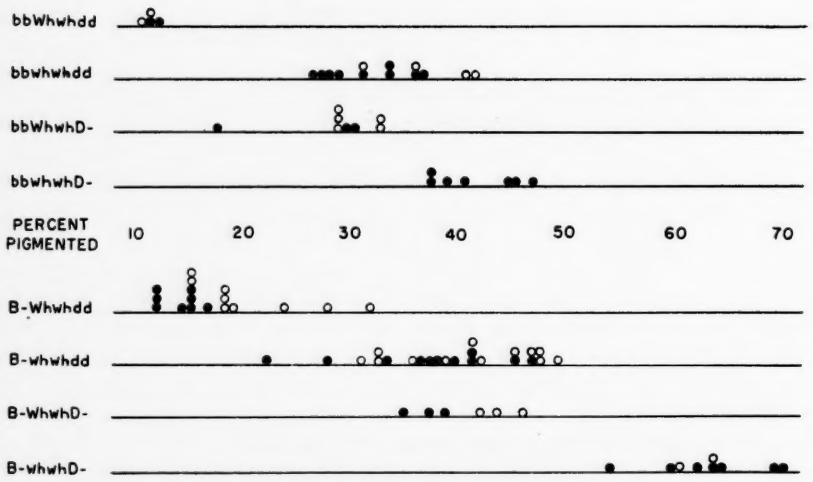
TABLE I. Results of various crosses involving *Wh*.

Class of mating		Character of offspring: intense color *whwh*	reduced color *Whwh*	no color *WhWh*
whwh × *whwh*	exp.:	52	0	0
	obs.:	52	0	0
Whwh × *whwh*	exp.:	208.5	208.5	0
	obs.:	201	210	6*
Whwh × *Whwh*	exp.:	212.5	425	212.5
	obs.:	218	415	217
WhWh × *Whwh*	exp.:	0	11	11
	obs.:	0	9	13
WhWh × *WhWh*	exp.:	0	0	16
	obs.:	0	0	16

*These six animals are quite certainly true albinos, *cc*, rather than whites, *WhWh*, since the male first mated with the original mutant *Whwh* female was a Swiss-Bagg albino. *After it was realized that homozygous animals were white these first sublines were discarded and new lines, using the original female and C57 Black and *dba* males, were created to obviate the confusion that might result from the presence of *c* in the strain.

*Results here reported were obtained incidentally to work carried on for the Manhattan Project at the University of Rochester under contract number W-7401-eng-49.

†Now of the Department of Zoology, University of Florida.



AGE SHIFT IN PIGMENTATION
Figure 7

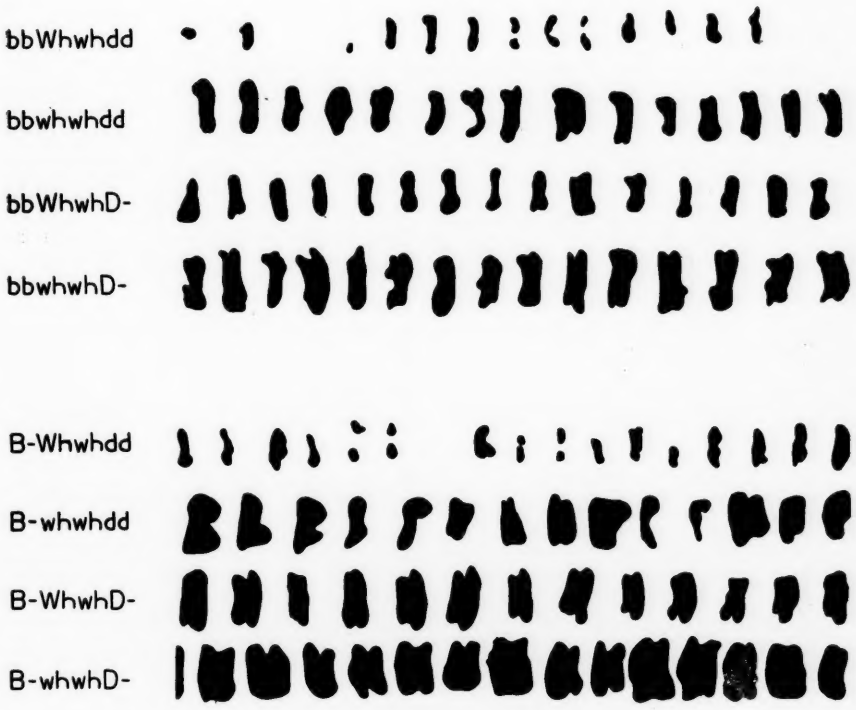
A comparison of the proportion of medullary pigment in the hairs of mice with various genotypes as indicated. Each symbol represents the proportion of a length of a hair (cf. Figure 8) that is occupied by medullary pigment. These per cent figures may also be read as microns since the unit of hair for measurement was a 100-micron length. Solid symbols indicate readings from mice approximately 46 days old; the hollow symbols, from the same mice 30 days later.

measurements of the widths of the bands were made along this line. The sums of the widths, in microns, in each 100 micron section provided a measurement representing the amount, or concentration, of pigment in the hair. This technique differs from the one used by E. Russell* to measure hair pigments; she counted the granules in individual medullary cells while we measured the widths of successive medullary cells in a length of hair.

The measurements (expressed in per cent) so obtained from 87 hairs involving about a dozen mice are summarized in Figure 7. The higher the number is, the greater the amount, or the dispersion, of the pigment in the hair; consequently, the darker is the color. Examples of tracings from which these measurements were made are shown in Figure 8. This technique of itself does not permit accurate genotypic identification of hairs since there is a great deal of overlapping of values. Combined with other factors such identifications could be made, however. For example, *Wh* reduces or restricts medullary pigment in a more regular fashion than does *d*. With a little practice one is able to distinguish between browns and blacks under the microscope. If hairs are removed from the same general areas from mice of like ages and a comparative approach is used, the key†, which contains additional information, should prove to be an accurate aid in the identification of mice in the classes considered. Zig-zag hairs are used; the first section is that length of hair distal to the first (distal) bend and the third section lies between the second and third bends.

Whwh mice darken slightly with age as is indicated in Figure 7 by comparing

*Russell, Elizabeth S. *Genetics* 31:327-346. 1946.
†See opposite page.



RELATION OF THREE GENES TO PIGMENT BANDS

Figure 8

Tracings of medullary pigment bands in 100-micron lengths of third sections of typical zig-zag hairs from mice of various genotypes involving *Wh*, *d*, and *b*.

Key to Identification of Pigment

1.	Medullary pigment clumped sporadically throughout the hair	2
1.	Medullary pigment in fairly even bands throughout the hair	5
2.	Medullary pigment in third section black	3
2.	Medullary pigment in third section brown or yellowish-brown	4
3.	Cortical pigment in tip absent	*B-ddWhwh*
3.	Cortical pigment in tip sparse black granules	*B-ddwhwh*
4.	Cortical pigment in tip absent	*bbddWhwh*
4.	Cortical pigment in tip sparse yellowish brown granules	*bbddwhwh*
5.	Medullary pigment in third section black	6
5.	Medullary pigment in third section brown	7
6.	Cortical pigment in tip and in first section has yellowish cast, and medullary bands in first section are narrow	*B-D-Whwh*
6.	Cortical pigment in tip and in first section has brownish black color and is solid dark brown between medullary bands which are wide	*B-D-whwh*
7.	Medullary bands in first section are very small, narrow, yellowish, some occasionally missing	*bbD-Whwh*
7.	Medullary bands in first section large, definite, and yellowish brown	*bbD-whwh*

the solid and hollow symbols within each genotype where a sufficient sample is represented. Our original female, *B-Whwh*, though, was quite distinguishable from black, *B-whwh*, at the age of 338 days. The rate of darkening is somewhat greater in dilute than in *White* mice.

It is not easy to distinguish dilute and *Whwh* mice by coat color alone. The pigmentation of the extremities is, however, different. In such *White* mice the feet and tail are light which is not the case with dilute.

In addition to reduced pigmentation of the coat and extremities, the eyes are affected; they tend to be very dark ruby (rather than black) in *B-D-Whwh* mice; they are definitely red in *B-dd Whwh* animals; and they are pink and pigmentless in - - - - *WhWh* individuals.

In several sublines a white ventral spot is present. In the lines in which these are most extensively developed an occasional white mark is found on the dorsum.

Homozygous white mice have been compared with Swiss-Bagg albinos; they differ in two respects. Our *White* mice are smaller than the albinos. When taken out of a dark pen into a well-lighted room the eyes of the *Whites* seem to be relatively smaller than those of the albinos. Whether this is due to squinting or an actual difference in the size of the eyeball is uncertain.

The gene, *Wh*, is also accompanied by decreased fertility. Table II shows the number of young produced by various kinds of matings with environmental factors subequal and randomized. The segregation of the alleles of *White* seems to be independent of sex.

TABLE II. Litter size of *Wh* matings.

Mating	Mean litter size	Number of litters
whwh × *whwh*	9.3	6
Whwh × *whwh*	8.3	85
Whwh × *Whwh*	7.1	217
WhWh × *Whwh*	6.0	7
WhWh × *WhWh*	3.7	12

◆

MAD *and* MUDDLED

MR. Porter Sargent puts out an annual Handbook for Private Schools. Before he gets around to rating the schools, he spends a few score pages enthusiastically berating the educational system, the government and the world at large. This blast he reprints as a separate book.

The current installment is titled *Mad or Muddled*. Mr. Sargent has a trenchant pen, and there's much meat in what is said. Sawdust runs out of every pompous personage, real, corporate, or legislative, Mr. Sargent sticks his pen into. Maybe the world is such a mess nothing but muddled madness is possible. But the proposed solution, such as it is, seems muddled too: "In a world palsied with unnecessary fears, those who retain their poise and sanity lose their popular appeal. . . . The greatest casualty of the war, is not the dead, God rest their souls . . . it's the lopping off of the growing part of the human intellect. . . . 'What Education Might Be' is another story which should begin with that grand old poem, the first chapter of *Genesis*, and should go on to reveal more of the Creator's work and prepare us for a fuller life amid all the resources of God's creation of which our educated have made a cesspool."

If we *could* get back to Genesis I, it would be *wonderful*. But it is regressive muddling, surely, to hope for salvation through racial return to an embryonic stage.—R. C.

*SARGENT, PORTER. *Mad or Muddled.* Or are we merely misled, misinformed, mis-educated? Who is responsible for the world's present shape? $2.00. pp. 190. 11 Beacon Street. Boston 1947.

Index to Volume XXXVIII

Journal of Heredity, 1947

A

Aivord, Rex M., Zygodactyly and Associated Variations in a Utah Family, 49.
Ancient Benefactors, W. C. Lowdermilk, 156.
Animal Genetics:
Animal Cytology and Evolution (Rev.), 21.
Cat, Polydactyly, 107; Temperament, 274.
Cattle, Breeding in India, 23; coat color, 271; Holstein-Friesian Spotting, 99.
Chironomus, chromosome IV of, 235.
Coat Color, Physique, and Temperament, 271.
Drosophila, an early description, 195.
Fowl, Polydactyly (Diplopodia), 67; sex reversal, 320; thiouracil effect on feathers, 41, 113.
Gene Therapy, 294.
Horses, temperament and color, 272.
Mice, Audiogenic Seizures, 3, 53; longevity of yellow, 40; "Snowy-Belly", 215; Temperament and color, 276; White mutants, 381.
Mink, mendelian ratios, 380; Screw Neck, 203; temperament, 275.
Polydactyly, in cats, 107; in fowl, 67; in Tiger Salamander, 291.
Rat, Linkage, of shaggy, 341; of fawn, 343; temperament and color, 276.
Sciara, Chromosome evolution, 279.
Sex Reversal, in fowl, 320.
Sheep, freemartin, 149; leg color, 89.
Swine coat color, 121; and temperament, 274.
Wasps, Melittobia and other, 11.
Anophthalmos, 174.
Apples, Chimeral sports, 371.
Arnsdorf, Robert E., Hen Into Rooster, 320.
Artificial Insemination in England, 214.
Ascorbic acid, in strawberries, 363.
Ashley, Laurence M., Bilateral Anophthalmos in a Brother and Sister, 174; Inheritance of Streblomicrodactyly, 93.
Association of Diabetes and Taste-Blindness, M. C. Terry, and Gabriel Segall, 135, 378.
Atchison, Earlene, Cytogeography of Gleditsia and Mitchella, 311.
Atom Bomb, Genetic Effects of, 137.
Audiogenic seizure, 3, 53.

B

Bacterial Disease in Tobacco, 35.
Baldwin, J. T., Jr., Hevea: A First Interpretation, 54.
Barbara Burks Memorial Fund, 152.
Barrer, Lester A., Unilateral Hexadactyly in Man, 345.
Beadle, G. W., The Chemistry and Biology of Nucleic Acid (Rev.), 346.
Benedict, L. I. *et al.*, A Recessive Naked-Seed Character in Upland Cotton, 313.
Bilaterial Anophthalmos in a Brother and Sister, Laurence M. Ashley, 174.
Birthrate, College, 355; U. S. 1946, 28.
Bishop, David W., Polydactyly in the Tiger Salamander, 291.
Bittersweet, hybrid, 125.
Blaser, H. Weston *et al.*, Chimeral Sports of Apples, 371.
Blindness, and Heredity (Rev.), 76; congenital, 174, 307.
Bohn, G. W., Colchicine Treatments for Use with Tomatoes, 157.
Books and World Recovery, 48.
Books Reviewed:
Benda, Clemens E., Mongolism and Cretinism, 83, 177.
Chandrasekhar, S., India's Population, 9.
Chisholm, G. B., The Re-establishment of Peacetime Society, 240.
Danielli, J. F. and Brown, B. (Editors), Nucleic Acid, 346.
Dunn, L. C., and Dobzhansky, Theodosius, Heredity, Race and Society, 299.
Frank, Robert, Personal Counsel, a Supplement to Morals, 160, 256.
Gates, R. Rugges, Human Genetics, 139.
Lea, D. E., Actions of Radiations on Living Cells, 209.
Muller, H. J., C. C. Little and L. H. Snyder, Genetics, Medicine, and Man, 336.
Ratcliff, J. D. (Editor) Science Year Book of 1947, 366.
Sargent, Porter, Mad or Muddled, 384.
Sperling, Abraham P., Psychology for the Millions, 127.
Weaver, Warren (Editor) The Scientists Speak, 366.
White, M. J. D., Animal Cytology and Evolution, 21.
Yahres, Herbert, What Do You Know About Blindness?, 76.
Bowden, Wray M., and Orland E. White, Oriental and American Bittersweet Hybrids, 125.
Brahman Cattle, breeding, 23.
Breeding Strawberries for Vitamin C, George M. Darrow *et al.*, 363.
Briquet, Raul, Jr., and Jay L. Lush, Heritability of Amount of Spotting in Holstein-Friesian Cattle, 99.
Brues, Austin M., Genetic Effects of the Atom Bomb, 137.
Burks, Barbara, Memorial Fund, 152.

C

Case of Sex-Linked Microphthalmia, F. E. Stephens, 307.
Castle, W. E. and Helen Dean King, Linkage Studies of the Rat, 341, 343.
Cattle Breeding in India, Fred B. Ogilvie, 23; Temperament and color, 272.
Cats, Temperament and color, 274.
Cats, Temperament and color, 274; polydactyly, 107.

Charles, Donald R. and Arnold B. Grobman, Mutant White Mice, 381.
Chemical reactions and mutations, 261.
Chemistry and Biology of Nucleic Acid (Rev.), 346.
Chironomus, Chromosomes, 235.
Chimeral Sports of Apples, John Einset *et al.*, 371.
Chimeras in the Pineapple, K. R. Kerns and J. L. Collins, 323.
Chromosome, rearrangement, 265; of chironomus, 235; of sciara, 279; of Sorghum, 251.
Chromosome Evolution in Sciara, Helen V. Crouse, 279.
Clayton, E. E., Wildfire Resistant Tobacco, 35.
Coat Color, Physique, and Temperament, Clyde E. Keeler, 271.
Colchine treatments, of peaches, 77; of pears, 189; of pineapples, 323; of tomatoes, 157; of triticales, 167.
Colchicine Treatments for Use with Tomatoes,, G. W. Bohn, 157.
Cole, Leon J., and Richard M. Shackelford, "Screw Neck" in the Pastel Color Phase of Ranch-Bred Mink, 203.
College Birthrate, Clarence J. Gamble, 355; eugenics, 199.
Collins, J. L. and K. R. Kerns, Chimeras in the Pineapple, 323.
Color on the Legs of Sheep, Clair E. Terrill, 89.
Color inheritance of the Sesame Flower, 221.
Cook, Robert C., Blindness and Heredity (Rev.), 76; Destiny by Catch-Words (Rev.), 240; Leonard Lyons Science Reporting (Rev.), 127; Mendel's 125th Birthday Anniversary, 161; Personal Counsel (Rev.), 160, 256; Puerto Rico Marches On, 45; R. A. Emerson, 353; and Jay L. Lush, Genetics for the Million (Rev.), 299.
Corcoran, John, Sonic Mousetrap Pictures, 3, 53.
Cotton, Fuzzy leaf, 153; naked seed, 313.
Crouse, Helen V., Chromosome Evolution in Sciara, 279.
Cytogenetics, of Hevea, 54.
Cytogeography of Gleditsia and Mitchella, Earlene Atchison, 311.
Cytology of Evolution and Evolution of Cytology (Rev.), 21.

D

Danforth, C. H., Heredity of Polydactyly in the Cat, 107.
Danish eugenics card index, 96.
Darlington, C. D., A Revolution in Soviet Science, 143.
Darrow, George M. *et al.*, Breeding Strawberries for Vitamin C, 363.
Dermen, Haig, Inducing Polyploidy in Peach Varieties, 77; Polyploid Pears, 189.
Destiny by Catch-Words (Rev.), 240.
Destruction of the Roscoe B. Jackson Memorial Laboratory, 288.
Diabetes and taste blindness, 135, 378.
Dice, L. R., Graduate Assistantship in Human Genetics, 188.
Diet-Induced Feather Modification in the Fowl, Mary Juhn and M. A. Jull, 41.
Diplopodia: A Lethal Form of Polydactyly in Chickens, Lewis W. Taylor and C. A. Gunns, 67.
Dobzhansky, Th., Cytology of Evolution and Evolution of Cytology (Rev.), 21; N. I. Vavilov, a Martyr of Genetics, 227.
Dogs, Temperament and color, 274.
Dodge, Stanley D., Jargon of Science, 32.
Drosophila, early description of, 195.
Dufur, Theodore B., The G. I. at College, 199.

E

Early Description of Drosophila, B. Peyer, 195.
Ecology of Hevea, 54.
Effects of Thiouracil on Feather Pigment Determination in Hybrid Fowl, Mary Juhn, 113.
Eighth International Genetics Congress, see Genetics Congress.
Einset, John *et al.*, Chimeral Sports of Apples, 371.
Emerson, R. A., 353.
Enigma of India (Rev.), 9.
Eugenics, see *Human Genetics.*
Ewen, Alastair H. and Frances A. Hummason, An Ovine Freemartin, 149.
Eyeless children, 174.

F

Falconer, D. S., Genetics of "Snowy-Belly" in the House-Mouse, 215.
Familial Lobster-Claw, Edith L. Potter, and Luella Nadelhoffer, 331.
Flesh Color in Hybrids of Tomato, J. W. and Margaret Mann Lesley, 245.
Fowl, see Animal Genetics.
Foxes, Temperament and color, 274.
Fraction Method of Analysis of Factors, Melvin D. Jones, 368.
Freemartin, sheep, 149.
Fuzzy Leaf in Cotton and its Association with Short Lint, D. M. Simpson, 153.

G

Gamble, Clarence J., The College Birthrate, 355.
Garber, E. D., The Pachytene Chromosomes of Sorghum Intrans, 251.
Gene Therapy, Clyde E. Keeler, 294.
Genetic Differences in Fatal Audiogenic Seizures, Calvin S. Hall, 3, 53.
Genetic effects of the atom bomb, 137.
Genetics Congress, 64, 105, 202, 289, 368.
Genetics and the Evolution of Civilization (Rev.), 336.
Genetics fellowship, 293; assistantship, 188.
Genetics for the Million (Rev.), 299.
Genetics of Sesame, D. G. Langham, 221, 347, 350.
Genetics of "Snowy-Belly" in the House-Mouse, D. S. Falconer, 215.
G. I. at College, Theodore B. Dufur, 199.

Goodale, H. D., "Predestined" or "Omnigenic" —?, 192.
Graduate Assistantship in Human Genetics, Dr. L. R. Dice, 188.
Grobman, Arnold B. and Donald R. Charles, Mutant White Mice, 381.
Gunns, C. A., and Lewis W. Taylor, Diplopodia: A Lethal Form of Polydactyly in Chickens, 67.
Guttmacher, Alan F., Genetics and the Evolution of Civilization (Rev.), 336.

H

Habrobracon, toxic influence of, 14.
Hall, Calvin S., Genetic Differences in Fatal Audiogenic Seizures, 3, 53.
Hands, abnormal, 49, 331, 345.
Hen Into Rooster, Robert E. Arnsdorf, 320.
Heredity of Polydactyly in the Cat, C. H. Danforth, 107.
Heritability of Amount of Spotting in Holstein-Friesian Cattle, Paul Briquet, Jr., and Jay L. Lush, 99.
Hetzer, H. O., Inheritance of Coat Color in Swine, 121.
Hevea: A First Interpretation, J. T. Baldwin, Jr., 54.
Hexadactyly, unilateral in man, 345.
Hires, William L., That Settles It!, 310, 233.
Holstein-Friesian cattle, 99.
Horses, temperament and color, 272.
How Many a's in Aardvark? (Rev.), 366.

Human Genetics, Eugenics, etc.:

Anophthalmos, 174.
Artificial Insemination in England, 214.
Birthrate, college, 355.
Birth Statistics for 1946, 28.
Blindness, 76, 174, 307.
Danish card index, 96.
Diabetes and PTC, 135, 378.
Fellowship, 188.
Genetics and the evolution of civilization (Rev.), 336.
Genetics for the Million (Rev.), 299.
Genetic effects of the atom bomb, 137.
G. I. at College, 199.
Hands, abnormal, 49, 331, 345.
Hexadactyly, unilateral, 345.
Lobster-claw, 331.
Malocclusion inherited, 117.
Medical genetics in the press, 22.
Microphthalmia, 307.
Mongolism, (Rev.), 83, 177.
Muscle, absence of in forearm, 7.
Mutations and temperament, 276.
Phenotype and temperament, 276.
Polydactyly, 49.
Population, of India, (Rev.), 9; of Puerto Rico, 45, 131.
Psychiatry and eugenics, (Rev.), 240.
PTC, unusual familial reaction, 377; diabetes and, 135, 378.
RH antibodies and feeblemindedness, 253.
Sex and the gamble of selection, 336-340.
Skin color and mixed marriages, 233, 310.
Streblomicrodactyly, 93.
Syndactyly, 49.
Teeth, crooked, 117.
Tongue curling, 365.
Zygodactyly, 49.
Human Genetics (Rev.), 139.
Hummason, Frances A., and Alastair H. Ewen, An Ovine Freemartin, 149.
Hutchins, Margaret C. *et al.*, Breeding Strawberries for Vitamin C, 353.
Hutt, F. B., Odd Familial PTC Reaction, 377.

I

Iltis, Hugh H., A Visit to Gregor Mendel's Home, 163.
Imhofe, Barbara *et al.*, Chimeral Sports of Apples, 371.
Inducing Polypoidy in Peach Varieties, Haig Dermen, 77.
Inheritance of Callus Formation and Seed Shedding in Sorghum, R. E. Karper and J. R. Quinby, 211.
Inheritance of Coat Color in Swine, H. O. Hetzer, 121.
Inheritance of Malocclusion, S. Edmund Stoddard, 117.
Inheritance of Streblomicrodactyly, Laurence M. Ashley, 93.
Intraindividual Variability of Chromosome IV of Chironomus, Curt Kosswig and A. Shengun, 235.
Ionizing Radiation and the Cell (Rev.), 209.
Italian Zootechnical Society Formed, 330.

J

Jackson Memorial Laboratory, destruction of, 288.
Japanese Long-tailed Fowl, 41.
Jargon of Science, Dr. Stanley D. Dodge, 32.
Jones, Melvin D., The Fraction Method of Analysis of Factors, 368.
Juhn, Mary, Effects of Thiouracil on Feather Pigment Determination in Hybrid Fowl, 113; and Jull, M. A., Diet-Induced Feather Modification in the Fowl, 41.
Jull, M. A. and Mary Juhn, Diet-Induced Feather Modification in the Fowl, 41.

K

Karper, R. E. and J. R. Quinby, The Inheritance of Callus Formation and Seed Shedding in Sorghum, 211.
Keeler, Clyde E., Coat Color, Physique, and Temperament, 271; Gene Therapy, 294; and Larry Moore, Note on Certain Mendelian Ratios in Mink, 380.
Kerns, K. R. and J. L. Collins, Chimeras in the Pineapple, 323.
King, Helen Dean and W. E. Castle, Linkage Studies of the Rat, 341, 343.
Kosswig, Curt, and A. Shengun, Intraindividual Variability of Chromosome IV of Chironomus, 235.

L

Langham, D. G., Genetics of Sesame, 221, 347, 350; Three Useful Gadgets for Plant Breeders, 29.

Leonard Lyons Science Reporting (Rev.), 127.
Lesley, J. W., and Margaret Mann Lesley, Flesh Color in Hybrids of Tomato, 245.
Linkage Studies of the Rat, W. E. Castle and Helen Dean King, 341, 343.
Lobster-Claw, 331.
Lowdermilk, W. C., The Ancient Benefactors, 156.
Lush, Jay L., and Raul Briquet, Jr., Heritability of Amount of Spotting in Holstein-Friesian Cattle, 99.
Lush, Jay L. and Robert Cook, Genetics for the Million (Rev.), 299.
Lysenko, T. D., 143, 230.

M

Macklin, Madge T., and Laurence H. Snyder, More Wishful Thinking About Mongolian Imbecility (Rev.), 83, 177.
Malocclusion, 117.
Man, Temperament and color, 276.
Medical Genetics Marches On in the Press, 22.
Mendel's Home, 163; 125th Birthday Anniversary, 161.
Mentzel, "discovers" Drosophila, 195.
Methods for Producing Triticales, S. J. Wellensiek, 167.
Mice, see *Animal Genetics.*
Microphthalmia, 307.
Milk Production in Indian Cattle, 23.
Mink, mendelian ratios, 380; "screw-neck", 203; temperament and color, 275.
Missing Forearm Muscle, M. F. Ashley Montagu, 7.
Mongolism (Rev.), 83, 177.
Montagu, M. F. Ashley, Missing Forearm Muscle, 7.
Moore, Larry and Clyde E. Keeler, Note on Certain Mendelian Ratios in Mink, 380.
More Wishful Thinking About Mongolian Imbecility (Rev.), 83, 177.
Muller, H. J., The Production of Mutations, 259; Twin Needs of Science, 258.
Mutant White Mice, Arnold B. Grobman and Donald R. Charles, 381.
Mutations, the production of, 259.

N

Nadelhoffer, Luella and Edith L. Potter, A Familial Lobster-Claw, 331.
National Research Council Announces Fellowships, 335.
Negro-White marriages, 233, 310.
News of the Eighth International Genetics Congress, 105. (See also, *Genetics Congress.*)
Nicotiana hybrids, 35.
1946 Breaks Birth-Record, 28.
Nobel Laureate in Sweden, 258.
Note on Certain Mendelian Ratios in Mink, Larry Moore and Clyde E. Keeler, 380.
Nucleic Acid, Chemistry and Biology of (Rev.), 346.

O

Odd Familial PTC Reaction, F. B. Hutt, 377.
Ogilvie, Fred B., Cattle Breeding in India, 23.
Oliver, C. P., Human Genetics (Rev.), 139.
"Omnigenic", defined, 192.
On to Stockholm, 202.
Oriental and American Bittersweet Hybrids, Orland E. White and Wray M. Bowden, 125.
Ovine Freemartin, Alastair H. Ewen and Frances A. Hummason, 149.

P

Pachytene Chromosomes of Sorghum Intrans, E. D. Garber, 251.
Peach, Polyploidy in, 77.
Pears, Polyploid, 189.
Peromyscus, Temperament and color, 275.
Personal Counsel (Rev.), 160, 256.
Peyer, B., Early Description of Drosophila, 195.
Phenylthiocarbamide, see PTC.
Pineapple, Chimeras in, 323.

Plant Genetics:
Ancient plant breeders, 156.
Apples, chimeral sports, 371.
Bittersweet hybrids, 125.
Breeders, three useful gadgets for, 29.
Cotton, fuzzy leaf, 153; recessive naked seed, 313.
Cytogeography of Gleditsia and Mitchella, 311.
Hevea, cytogenetic survey of, 54.
Honey locust, cytogeography of, 311,
Mendel anniversary, 161.
Partridge berry, cytogeography of, 311.
Peach, polyploidy, 77.
Pears, polyploid, 189.
Pineapple chimeras, 323.
Polyploidy, in apples, 371; in peaches, 77; in pears, 189; in pineapple, 323.
Rye-wheat hybrids, 167.
Sesame, flower color, 221, morphology, 347; plant color, 350.
Sorghum, Pachytene Chromosomes, 251; seed shedding, 211.
Strawberries, breeding for vitamin C, 363.
Tobacco, wildfire resistant, 35.
Tomatoes, colchicine treatment, 157; flesh color, 245.
Wheat-Rye Hybrids, 167.
Polydactyly in the Cat, 107; in chickens, 67; in man, 49. in the Tiger Salamander, David W. Bishop, 291.
Polyploid Pears, Haig Dermen, 189.
Polyploidy, in apples, 371. in peach varieties, 77. in pineapples, 323.
Population Pressures and the Future of Puerto Rico, Clarence Senior, 131.
Postscript on the Diabetes-non-tasting Correlation, 135, 378.
Potter, Edith L. and Luella Nadelhoffer, A Familial Lobster-Claw, 331.
"Predestined" or "Omnigenic"—?, H. D. Goodale, 192.
Production of Mutations, H. J. Muller, 259.
Psychology (Rev.), 127.

PTC, and Diabetes, 135, 378; an unusual reaction to, 377.
Puerto Rico Marches On, R. C. Cook, 45; Population, 131.
Putman, Helen, Fellowship for Advanced Research, 293.

Q

Quinby, J. R., and R. E. Karper, The Inheritance of Callus Formation and Seed Shedding in Sorghum, 211.

R

Rabbits, temperament and color, 275.
Raccoon, temperament and color, 275.
Radiation and the Cell, (Rev.), 209.
Radiation-Effects, 137, 262.
Rat, see *Animal Genetics.*
Recessive Naked-Seed Character in Upland Cotton, J. O. Ware, L. I. Benedict and W. H. Rolfe, 313.
Revolution in Soviet Science, C. D. Darlington, 143.
RH Antibodies in Mothers of Feebleminded Children, Mary Louise L. Scholl, Warren E. Wheeler, and Laurence H. Snyder, 253.
Rolfe, W. H. *et al.*, A Recessive Naked-Seed Character in Upland Cotton, 313.
Rubber Production, 54.
Russian Genetics, 143, 227; Social Science, 219.
Rye-Wheat Hybrid, 167.

S

Salivary Gland chromosome of sciara, 279.
Sax, Karl, Ionizing Radiation and the Cell (Rev.), 209.
Scholl, Mary Louise L., Warren E. Wheeler, and Laurence H. Snyder, RH Antibodies in Mothers of Feebleminded Children, 253.
Sciara, Salivary Chromosomes of, 279.
Scott, D. H. *et al.*, Breeding Strawberries for Vitamin C, 363.
"Screw Neck" in the Pastel Color Phase of Ranch-Bred Mink, Richard M. Shackelford and Leon J. Cole, 203.
Seed Shedding in Sorghum, 211.
Segall, Gabriel, and M. C. Terry, Association of Diabetes and Taste-Blindness, 135, 378.
Senior, Clarence, Population Pressures and the Future of Puerto Rico, 131.
Sesame, see *Plant Genetics.*
Sex, and the Gamble of Selection, 340; Determination in Wasps, 11; —Linkage, Microphthalmia, 307; reversal, 320.
Shackelford, Richard M., and Leon J. Cole, "Screw Neck" in the Pastel Color Phase of Ranch-Bred Mink, 203.
Sheep, Temperament and color, 274. Leg-color, 89; freemartin, 149.
Shengun, A., and Curt Kosswig, Intraindividual Variability of Chromosome IV of Chironomus, 235.
Simpson, D. M., Fuzzy Leaf in Cotton and its Association with Short Lint, 153.
Skin Color of Children from White by Near-White Marriages, Curt Stern, 233, 310.
Snyder, Laurence H., *et al.*, RH Antibodies in Mothers of Feebleminded Children, 253.
Social Science, Jargon, 32; in the Soviet Union, 219.
Some Experiments with Melittobia and Other Wasps, P. W. Whiting, 11.
Sonic Mousetrap Pictures by John Corcoran, 3, 53.
Sorghum seed shedding in, 211; pachytene chromosomes of, 251.
Soviet Genetics, 143, 219, 227.
Squirrels, Temperament and color, 275.
Stark, Morton, How Many a's in Aardvark? (Rev.), 366.
Stephens, F. E., A Case of Sex-Linked Microphthalmia, 307.
Stern, Curt, The Skin Color of Children from White by Near-White Marriages, 233, 310.
Stoddard, S. Edmund, Inheritance of Malocclusion, 117.
Strawberries, breeding for vitamin C, 363.
Streblomicrodactyly, 93.
Swine, Temperament and color, 274; coat color, 121.
Syndactyly in Man, 49.

T

Tasteblindness and Diabetes, 135, 378.
Taxonomy, of Hevea, 54.
Taylor, Lewis W., and C. A. Gunns, Diplopodia: A Lethal Form of Polydactyly in Chickens, 67.
Terrill, Clair E., Color on the Legs of Sheep, 89.
Terry, M. C., and Gabriel Segall, Association of Diabetes and Taste-Blindness, 135, 378.
That Settles It!, William L. Hires, 310, 233.
Thiouracil-treated Fowl, 41, 113.
Three Useful Gadgets for Plant Breeders, 29.
Tobacco, wildfire resistant, 35.
Tomatoes, see *Plant Genetics.*
Tongue Curling, 365.
Tooth defects inherited, 117.
Triticales, Methods for producing, 167.
Twin Needs of Science, H. J. Muller, 258.

U

Unilateral Hexadactyly in Man, Lester A. Barber, 345.
Urbanowski, Ann and Joan Wilson, Tongue Curling, 365.

V

Vavilov, a Martyr of Genetics, Th. Dobzhansky, 143, 227.
Visit to Gregor Mendel's Home, Hugh H. Iltis, 163.
Vitamin C, in strawberries, 363.
Vogt, William, Enigma of India, (Rev.), 9.

W

Ware, J. O. *et al.*, A Recessive Naked-Seed Character in Upland Cotton, 313.
Wellensiek, S. J., Methods for Producing Triticales, 167.
Wheat-rye hybrids, 167.
Whiting, P. W., Some Experiments with Melittobia and Other Wasps, 11.
Wheeler, Warren E., *et al.*, RH Antibodies in Mothers of Feebleminded Children, 253.
White, Orland E., and Wray M. Bowden, Oriental and American Bittersweet Hybrids, 125.
Wilcox, Marguerite S. *et al.*, Breeding Strawberries for Vitamin C, 363.
Wildfire Resistant Tobacco, E. E. Clayton, 35.
Wilson, Joan and Ann Urbanowski, Tongue Curling, 365.

X-Y-Z

X-ray, and the cell (Rev.), 209; and mutation, 263.
Yellow Mice and Differential Mortality, 40.
Zygodactyly and Associated Variations in a Utah Family, Rex M. Alvord, 49.

R. A. Emerson

(*Continued from page* 353)

cooperative pooling of information Emerson had no doubt. In 1943 he wrote as follows about the origin of the maize geneticists news letter: "I can plead only that I did not invent the maize ghost 'publication'—nor did anyone else. It just growed. It started with personal correspondence and exchange of material between my former students and me. Soon others, whom, I regret to say, I cannot claim as former students, came in. When the load became too heavy, Rockefeller funds came to our assistance. I believe it is an under-statement to say that the group of maize geneticists has accomplished twice as much because of this close cooperation as the several workers involved could have accomplished independently."

This statement is characteristic of Emerson who said in the writer's presence on another occasion that he never could think of his graduates as students: they seemed to him more like children of his own. E. M. East, another of the departed giants of the early days of genetics interjected the comment: "You're all wrong in your attitude, Emerson. I think of my students as younger brothers—not as children." But Emerson held to his position—said it gave him the right to be more demanding of good work of his former students. But Emerson was not the "Life With Father" kind of "parent."

Genetics of maize and of flies—and of man even—has moved very far in the span of a lifetime. This has happened because the new-born science, only now reaching "middle age' 'in terms of human life-spans, did have its giants in the early days—and among these men of great stature our departed friend stood very tall.—R. C.

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